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MANAGERIAL METHODS OF SUCCESSFUL PROJECT MANAGERS

WITH A LOOSE REIN

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by
George A. Steiner,
Director of the Division of Research and
Professor of Business Administration
and
William G. Ryan, Colonel, USAF (Ret.)
Lecturer

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PREFACE

This study sets forth the basic managerial philosophies, principles, and practices used by fifteen project managers in the aerospace industry. All operated in the research and development phase, and all were highly successful in producing a superior technical product at a minimum time and cost. All had some freedom from the typical massive and tight regulations placed on large mass-production procurement projects.

This study was undertaken with the hope that better understanding of how successful loose-rein managers really managed would lead to more use of this technique on NASA and military programs. If this objective is achieved it will be necessary to arrest and reverse a current opposite trend.

The research was supported by a grant from the National Aeronautics and Space Administration and was designed to contribute directly in the application of its procurement regulations. We are grateful for NASA's support and confident this study will be of assistance to the Agency.

This first draft is presented for discussion at a research seminar to be held at UCLA in April 1966. Those invited will include project managers interviewed together with selected officials from NASA, the Department of Defense, and other interested scholars and practitioners.

William Ryan was principally responsible for writing Part III and George A. Steiner was primarily responsible for the remainder of the paper. Thanks are due to John Rennie, a part-time research assistant, and to Marilyn McElroy and Marcy Fortier, who handled various clerical and typing details.

We wish to express our appreciation for the patience and generous help of the project managers interviewed while we were learning from them. We hope we have properly reflected what we saw and heard. Naturally, they are not responsible for the way this report was prepared.

G.A.S.
W.G.R.

INTRODUCTION

This study is the result of depth interviews with a selected group of project managers who had varying degrees of latitude and who were successful in making a complicated prototype in a time and for a cost under what would have been likely had they not operated under a loose rein. Contained in this Report in Part II is the first comprehensive effort, to the best of our knowledge, to develop a detailed model of the fundamental managerial philosophies and practices of such project managers.

A major purpose of this study is to focus more attention on the loose rein method, to describe and analyze the managerial practices that are typically used, and to set forth advantages in the process for both the government and its contractors. If this study results in only one new contract of fairly large dimensions permitting a loose rein, and if the contractor achieves the degree of success typically achieved by the project managers studied, the efforts of the study should be considered worthwhile. There should be substantial savings in time and cost to prototype. But, it is our hope that this and studies like it will result in placing a few more medium-sized and many more small contracts permitting wide discretion for contractors.

It is our objective, too, to begin the compilation of a comprehensive managerial model for contractors to study. While the model is not a how-to-do-it prescription, it does present basic fundamental principles and practices which must be applied for success in cutting time and cost to prototype.

Finally, it is our hope that scholars and practitioners will add to this model, perfect it, and develop further its strengths and weaknesses. At this stage of the research, this Report cannot be considered a definitive treatment of the subject. It is just a beginning.

Despite the recommendations of high government officials for loosening procurement reins under appropriate conditions,[1/] and despite expressed official intentions to permit more flexibility,[2/] the trend has been toward a tightening rather than a loosening of contractor regulations. This trend continues despite an increase in incentive contracting. It is examined in Part III.

This Report clearly is no polemic against government procurement regulations of contractors. Quite the contrary. We agree with the report of a Presidential task force which said: "...officials must be in a position to supervise the execution of work undertaken, and to evaluate the results. These are basic functions of management which cannot be transferred to any contractor if we are to have proper accountability for the performance of public functions and for the use of public funds." The report goes on immediately to say, however: "To say this does not imply that detailed administration of each research and development task must be kept in the hands of top public officials. Indeed, quite the contrary is true, and an appropriate delegation of responsibility—either to subordinate public officials or by contract to private persons or organizations—for the detailed administration of research and development work is essential

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1/ See, for example, Report to the President on Government Contracting for Research and Development (Washington, D.C., Office of the White House Press Secretary, Monday, April 30, 1962) (Mimeographed), p. 47-48.

2/ See, for example, "Management Trends in Defense Development and Production," a speech by The Honorable Graeme C. Bannerman, Assistant Secretary of the Navy (Installations and Logistics), at the DoD Advanced Planning Briefings for Industry, Ambassador Hotel, Los Angeles, California, March 3, 1965, p. 2.

to its efficient execution."[3/]

One assumption underlying the present research is that if patterns of managerial philosophy and practice can be found and identified among successful loose rein project managers, governmental contracting agencies might find it easier to loosen some control. If a contracting agency knows reasonably well how a project is likely to be managed if a loose rein is permitted, it is logical to suppose that it will be more likely to permit a loose rein than if it does not know how the project will be managed.

This study began with the hypothesis that successful project managers having a loose rein did in fact use comparable managerial principles and practices. The results of our study verify the truth of this hypothesis.

Definition of Loose Rein Project Management

Project management is a comparatively new term in management literature. A project manager has a number of characteristics that differentiate him from the typical line manager. A project manager is given responsibility for undertaking and bringing to a successful conclusion a specific project. When the task is completed, his organization is disbanded or he is given another limited job. He usually collects a team from employees in other parts of his organization who return to their regular posts when the job is done. In many organizations the project manager must get work done through employees in functional areas who report to functional managers. In such instances the authority of the project manager conflicts with that of the functional managers. Project managers working on research and development naturally must employ an unusually high proportion of total personnel from the ranks of scientists and engineers. This creates a new type of managerial

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[3/] Report to the President on Government Contracting, op. cit., p. 18-19.

problem which the typical line manager does not face.

A project manager having a loose rein is freed from most of the detailed procedural procurement requirements placed upon him by his customer. He has freedom in evaluating and reviewing requirements, in choosing design to meet requirements, and in making technical and managerial decisions needed to complete his assigned task. Naturally, there is a spectrum of freedom, from a virtually unlimited discretion at one pole to restrictions approaching total contractual control at the opposite pole. Most loose rein arrangements differ in degree from others. There is no single, generally-used operating model. But the concept in mind in this study is substantial freedom for the contractor as compared with the typical contract which incorporates requirements to comply with a myriad of regulations.

Current management literature identifies in a rough way what we are discussing here as "adaptive management environment," compared with "authoritarian environment." These are two polar classes of environment. There are other commonly-used terms to indicate these two types of management.[4/]

The Project Managers Interviewed

The following project managers were interviewed in depth, many more

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[4/] For a description of the meaning of "mechanistic" v. "organic," see Tom Burns and G. M. Stalker, The Management of Innovation (Chicago: Quadrangle Books, 1962); for "coercion-compromise" vs. "consensus-collaboration," see Management Factors Affecting Research and Exploratory Development (Cambridge, Massachusetts: Arthur D. Little, Inc., 1965); for "executive authority" vs. "colleague authority," see Simon Marcson, The Scientist in American Industry (New York: Harper Brothers, 1960); for "rational model" vs. "natural system model," see Alvin W. Gouldner, "Organizational Analysis," in Sociology Today: Problems and Prospects, eds. Robert K. Merton, Leonard Broom, and Leonard S. Cotrell, Jr. (New York: Basic Books, 1959); for "authoritarian" vs. "adaptive," see Arthur D. Little, Inc., op. cit.; and for "theory X" vs. "theory Y," see Douglas McGregor, The Human Side of Enterprise (New York: McGraw-Hill Book Company, Inc., 1960).

than once:

Becker, H. S.

Director of Launch Vehicles Group, Advanced Systems Department, North American Aircraft. (Project manager previously for three or four classified advanced projects. Now supervises several classified projects.)

Carlson, Clare G.

Manager of Guidance and Control Division, Hughes Aircraft. (Project manager previously for several fire control projects, including that for Clarence L. Johnson's RS 71.)

Chalmers, William

Director, Special Studies Staff, Systems Research and Analysis Division, T.R.W. Systems Group. (Project Director, Vela Hotel.)

Cleland, David I., Dr. (Major)

Assistant Professor and Assistant Head, Department of Systems Management, U.S. Air Force Institute of Technology. (Previously project manager, Airborne Command and Control System, KC 135, and project manager Bomarc.)

Dill, Albert (Colonel)

U.S. Air Force. Present duty is with Cost Analysis Branch, RAND. (Previously project manager, several classified projects, Air Force Satellite Center.)

Glaser, Paul

Director, Space Power and Support Systems Laboratory, T.R.W. Systems Group. (Sub-program manager, Orbiting Geophysical Observatory and Pioneer.)

Gleghorn, George, Dr.

Project manager, Orbiting Geophysical Observatory, T.R.W. Systems

Group. (Previously project manager, Pioneer.)

James, Jack

Assistant Laboratory Director, Lunar and Planetary Projects, Jet Propulsion Laboratories. (Previously project manager Mariner, Mars, and Venus Projects.)

Johnson, Clarence L.

Vice President of Advanced Development Projects, Lockheed-California Company. (Project manager for over forty projects, including the P-80, U-2, and RS 71.)

Sampson, William

Director of Group One, Aerospace Corporation. (Now supervises eleven managers of highly classified projects. Previously General Systems Engineering/Technical Direction project manager on classified satellite projects.)

Schimandle, W. J.

Assistant Voyager Capsule System Manager, Jet Propulsion Laboratory. (Assistant project manager, Mariner.)

Strauss, William

Assistant Division Manager, Guidance and Controls Division, Hughes Aircraft Corporation. (Project manager previously for several fire control projects.)

Taylor, Trude

President, Electronic Memories, Inc. (Subcontractor on Pioneer and Vela Hotel.)

Westmoreland, Lonnie (Colonel, USAF, Retired)

(Previously System Program Officer for Vela Hotel. Managed several classified A.E.C. projects.)

Wilson, H. G.

Associate Technical Director, Naval Ordnance Test Station, China Lake, California. (Supervisor of dozens of projects, including Sidewinder.)

While discussions with many students of project management and examination of the literature on the subject added to our knowledge, the major source of the descriptive model was derived from the above project managers. Our intention was to describe what we observed and were told by practitioners, not what they were thought by outsiders to do.

Many more projects are represented in this study, of course, than the numbers of men listed. These projects ranged from very small contracts to several in the $20 to $30 million range, and some over this figure. The degree of freedom of decision varied from comparatively little to restrictions of considerable tightness. (During the course of this research, which extended over a two-year period, the reins tightened on several of the projects.) The type of projects ranged from basic research through development to prototype. None of the projects examined were mass production operations, although some of the managers had prepared prototypes which eventually, under other managers, moved into large production runs.

On the basis of any reasonable set of standards all these project managers interviewed were successful. Their projects were technically superior; they also were made at lower cost and in better time than would have been the case had detailed procurement regulations been generally applicable. This is an assertion which this study did not seek to prove. On the surface, at least, it clearly is true.

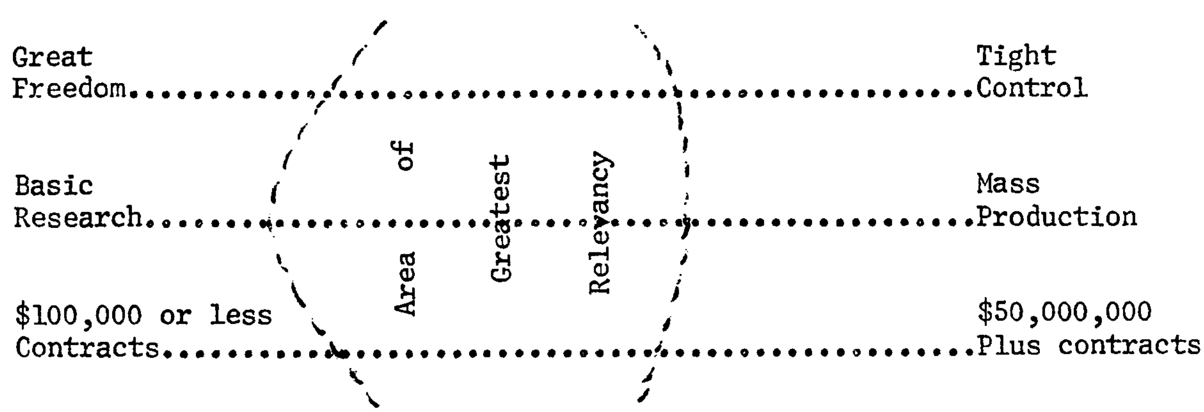
The organizational arrangements of the project managers varied from those having complete control of all in-house personnel working on the project, to those who had to get their work done by using employees reporting to their own functional managers. Authority of project managers, both legal and de jure, also varied considerably.

The Model and Its Limitations

Despite these differences, our study shows a substantial area of agreement on basic philosophies, and a substantial uniformity of pattern in managerial practices and techniques employed. While it may be premature to say that at an operational level of abstraction there is a general "composite" or "typical" operational managerial behavior, the results of our study show that most of the project managers studied did have a similar managerial philosophy and did embrace comparable managerial principles in practice.

The model may appear to include many truisms. This may be so, but they are identified as truisms which the project managers interviewed clung to above all others.

We think, while the model has applicability over a rather broad range of subject matter, it is clearly applicable in the mid-ranges of three spectrums. These are degrees of freedom, contract size, and nature of problem. Schematically this is shown in the following diagram.



This is to say that in developing the "typical" model it was the range sketched in the diagram that was in mind. This results from the fact that generally speaking the "typical" project examined rested in this area.

There are a number of important limitations in the use of this loose-rein model. They are set forth briefly in Part IV.

Limited resources were devoted to this particular product. More study clearly seems merited as a result of this research. Our observations about research which ought to be pursued to strengthen the model, to make it more convincing and useful, are contained in Part V of the Report.

Despite its limitations, this Report should at a minimum clarify the managerial frame of reference used by project managers having a loose rein. At the maximum, we hope it will stiffen the resolve of government contracting officers to loosen more than at present the reins on project managers in the research and development phases on smaller contracts. If this is done, we are convinced these projects are more likely to be done at a better time and cost to prototype, and be technically more superior.

II

MANAGERIAL METHODS EMPLOYED BY SUCCESSFUL PROJECT MANAGERS WITH LOOSE REIN: A MODEL

Introduction

It is said that when Polygnotus, the celebrated artist of ancient Greece, decided to paint Aphrodite he went to Crotona, a city having the most beautiful women of Greece. There he observed and studied their best features. From each he took something and combined his observations into one painting. The result was the most beautiful of all women, but the portrait did not look completely like any one.

The word model in this section likewise is a composite of observations from all project managers interviewed. This idealized model portrays the "typical" managerial principles and methods of the successful project manager having a loose rein from his customer. No one of the managers, however, acts precisely as the model prescribes.

This model contains our observations of the project managers together with what they told us. It is not an effort to accumulate what others have found and reported in the literature on the subject, except where such reference is useful to clarify a particular point. Naturally, the model contains many untested hypotheses. The most important ones remain for further research and are discussed in Part IV.

Our observations could, of course, be classified differently. The groupings of the model were chosen to highlight certain aspects of the managerial methods employed, particularly leadership, authority, staffing, planning, control, engineering, and customer relations. Naturally, a number of observations of a comparable nature fit into more than one category.

There is, therefore, a little overlapping of content.

The principles which are dominant and found in the management practice of those men interviewed are italicized. As used here, the word principle refers to a basic and fundamental rule, guide, or truth that the managers interviewed all seemed to consider of significance in their successful management.

Leadership of Staff

The project manager should be not only a coordinator of actions needed to achieve the objectives of the project, but he should be an architect, a leader of men in the highest sense of the term, and a superb organizer.

While the project manager may have a rather loose rein from the customer, his dealings with subordinates and others associated with the project vary from loose to very tight control, depending upon project progress and the subject of his actions. For example, in the early phases of a new project design, such as in the early days of the Sidewinder development, Dr. William B. McLean exercised a very loose rein over his staff. One of his major principles in developing a simple and effective design is that "the designer's freedom of expression and freedom of choice--as with the artist--should not be unduly hampered." He makes the case for this loose rein in these words: "Scientists and engineers are likely to be most creative when their supervision is such that they feel substantial freedom in their work--in selecting their problems and goals, in deciding on the approach to achievement, and in interpreting their data."[1]

But this freedom is not completely undirected. Quite the contrary.

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[1] William B. McLean, "The Art of Simple and Reliable Design," U.S. Naval Ordnance Test Station, China Lake, California (Reprint) Spring 1963, p. 2.

The typical project manager is an orchestra leader, an architect, in stimulating and organizing his team efforts. McLean explains this leadership requirement in these words: "Each of these men (the project team) must feel that he has the freedom to conduct his program as he believes best. Any restriction of this freedom automatically releases him from the responsibility of making the final gadget work. It is here that the designer must walk the high wire of maintaining maximum freedom for his workers while at the same time maintaining a rigid discipline regarding the need for simplicity. An iron will is needed to direct a concerted and devoted effort to do everything the simplest way possible, and in a manner that will make the complete system work."[2/] McLean is speaking about a team effort in developing a new, novel, yet simple design. But the principle also applies and is recognized as being important by project managers in later stages of project development.

H. Wilson, of the U.S. Naval Ordnance Test Station, China Lake, describes the importance of the "architectual" function of the project manager in these words: "The project leader is an architect. He is not solely a coordinator. Without an architect, you have a chairman of a committee. Committees have not been very effective in developing technological breakthroughs necessary in the research stage of projects in order to achieve the prototype at a minimum time and cost. The architect must be capable of understanding the experts under his control and knowing what to do with his advisors. He must exercise important direction in choosing among alternative courses of action in envisioning the total design, and in understanding the consequence of particular actions that are taken over

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[2/] Ibid., p. 5.

time which will have an impact on the ultimate design." Wilson's point is that a project leader, in order to cut time and cost to prototype, is a designer, a creater, a sort of orchestra leader. He is not solely a coordinator. He understands the technology involved. He is able to use his experts appropriately and in such a fashion as to stimulate the greatest possible productivity from them. He is able to organize in his own mind the great mass of information that is necessary to insure success.

Every one of the project managers interviewed seemed to have in abundance a capability to lead, to maintain a proper balance between freedom and restraint, and to secure high morale and creativity from the project team. Several project managers pointed out that staff became so excited about projects that it was necessary to check on the time spent on the job so as to avoid excessive preoccupation with project problems.

Each project manager, naturally, had a somewhat different problem and environment. Each also brought to the project leadership role a different background, set of values, and methods of operation. But each had a quality which Bismarck must have had in mind when he said: "It is easy enough to find a Minister of Education; all the job requires is a long white beard. But a good cook is different; that requires universal genius." These men were good cooks.

A most significant conclusion reached in the study is that while our "typical" project manager had a comparatively loose rein from the contractor there was little that was "loose" about his relations with those working on the project. Except in the basic research and design stages, the typical project manager applied specific, detailed, and frequently rigorous rules. His role as an orchestra leader was based upon the application of strict counterpoint.

Authority

The "typical" project manager the subject of this Report is one who operates across functional lines. He may work in a "matrix-type" organization, or he may gather a team from the functional areas and exercise direct control over them. He also usually must deal with functional organizations outside his company, such as at a launching site.

The authority of "our" project manager, therefore, cuts across functional lines. A conflict of authority does exist between him and the functional managers. The functional manager traditionally has complete authority within his function, subject to certain exceptions from his own superiors and headquarters' staff groups. Now, however, he must share authority with project managers.

The typical project manager must bring together at one point the managerial activities required to achieve the objectives of the project. The full scope of his activities embraces the entire range of what is usually thought of as the managerial function. He must plan, control, direct, staff, and organize. This involves some power in setting objectives, dealing with the customer, and producing the objects required to achieve the mission of the project. In doing all this he has no line authority in the functional areas.

What fundamental principles and practices are employed by the typical project manager interviewed? How did he view his problems?

The project manager should have broad authority over all elements of the project. His authority should be sufficient to permit him to engage all necessary managerial and technical actions required to complete the project successfully. He should have appropriate authority in design and the making of technical decisions in development. He should be able to control funds, schedule, and quality of product. If subcontractors are used, he should have maximum authority in their selection. He clearly has authority over his immediate staff, but also has authority, as well as responsibility and accountability, for the completion of the project with the time, cost, quality, and quantity requirements in the contract.

Chalmers, project manager of the Vela Hotel, pointed out that he had considerable flexibility in the designing of the satellite. The requirements and specifications for the original piece of equipment were set by the customer, but he had much flexibility in determining how to meet the specifications. Other project managers interviewed had, or desired, comparable relationships with the customer.

Project managers felt that flexibility in design had two major consequences of great help in cutting time and cost to prototype. First, ability to help develop design provided a challenge to imaginative people which resulted in a higher level of creativity. Second, the project manager had an opportunity to simplify design and tried to do so. One project manager observed: "Even though I might design something for the 'bird' that would increase the cost, be acceptable to the customer, and thereby raise the contract price and the possible profit, I would not do so if it complicated the design." One of the basic principles of design observed was: Keep all interfacing as simple as possible.

The project manager needs authority to resolve conflicts that may jeopardize achievement of project objectives. As one put it: "There is a natural tendency for the functional managers to standardize their operations or efforts, to perform to standards, or to build a standard model. A project manager must, through his influence, force his functional areas to depart from a standard and build something that fits in with the other parts of the project. Someone has to force these people to take action when these actions increase a functional manager's risk or use his resources at a greater rate than he would otherwise. The project manager's role is to balance this risk over all portions of the project. Therefore, he must have authority to move quickly to balance his risk."

One project manager engaged in correspondence for almost one year concerning a test of a launch vehicle. The manager of the launch vehicle sub-program refused to permit the test because he had many jobs, many customers, and his allocation of resources was insufficient to undertake the test. Finally, the project manager, citing his plan which had been approved, and operating on the ultimate authority of NASA 4-1-1, March 1963, ordered the test. The test was made.

<u>The project manager must have strong authority; everyone must know he has the authority and that he can and will use it when required</u>. Conflicts arise in development of the end item (such as those that concern weight, shape, or design) which the project manager must resolve. A third party is needed to resolve an impasse and to force one or another participant in the project to take an action which may increase the risk of failure or the risk of exhausting resources allocated to the project. The project manager has to balance risk across all of the project while each functional manager tends to consider costs and risks within his functional area. Sometimes the System Program Officer may make such decisions alone, or with the project manager. As one project manager put it: "Development projects represent advancements, they represent changes, and they represent innovations. You cannot get people to make changes without authority."

<u>The project manager must earn the respect of and gain authority over elements of the program which are not under his direct, formal authority</u>.

While the project manager may have legal authority, he gets most of his work done through influence and authority other than that legally extended.

The typical successful project manager gets things done through cooperation of others gained in many different ways. This may be a combination of forces, such as his status and respect enjoyed both within and outside his organization, his persuasive abilities, his reputation and capability in resolving opposed views, the priority of his project within and outside the organization, his specialized knowledge, and his rank in the organization.

Voluntary cooperation is better than that forced by legal power. But if informal authority does not work, then formal authority is needed. If a program manager asks an outside agency to take a risk, he should have either the authority to demand it or be able to pay the agency to take the risk.

<u>The project manager should have maximum control over budget, extending through the functional organization</u>. All project managers who discussed this matter with us felt that having control over budget was an indispensable means to effective cooperation.

<u>The project manager should not try to describe exactly the authority and responsibility of his immediate subordinates. He should encourage problem solving rather than role definition</u>. One project manager observed, for example, that one of his subordinates may have most of his authority, and interest, in design. He will also have other interests, and perhaps some authority, in other areas, such as launch, quality control, or production. It is meaningless, he said, to try to define precisely areas of authority in order to prevent gaps or overlaps, for when his chief of design finds a lax moment or there are important problems in quality control, he should help those directly responsible to solve them. This project manager

further observed that: "If you rigidly define authority, all you do is leave holes in the organization through which the big problems fall. However, if you go along with a 'Gaussian' distribution of authority, the overlaps insure that all problems are considered by someone."

It is the assumption of this project manager that the people most capable in solving a problem will step forward to help solve the problem. This seemed to have been borne out in his experience. In his group there was a general acceptance of leadership of the man with superior knowledge. In this fashion dual authority was prevented and conflict avoided.

This project manager believes that it is better to have a less precise definition of responsibility in the early stages of a project and to change the responsibilities in a time-phased manner as the project evolves. In the early phase of the project, for example, assignment emphasis should be on design problems. As the project progresses, when the design problems are for the most part solved, the assignment emphasis changes, e.g., to test.

There is a limit, of course, to such freedom. The larger the project, the more necessary it is to define authority and responsibility more precisely. All project managers concede this point.

Among projects in the design stage the team approach to problem solving was noticeable. This seems especially acceptable the higher the scientific expertise involved. It probably is partly responsible for the high morale as well as more than ordinary creativity found in the projects surveyed.

<u>The project manager has and accepts final authority in major engineering matters</u>. This is a matter which will be discussed later. It is included here, however, for it is an exercise of authority.

All project managers interviewed without exception felt that their authority in recent months has been eroded under new regulations and administrative interpretation of rules. They contend, too, that the results are greater time and costs to end product, and greater dangers of failure. More will be said about this matter later.

Staffing

The project manager should hold the size of his central project staff over which he exercises direct control to about ten people if possible but no more than thirty. All project managers interviewed asserted it was essential to hold the central project staff to relatively small numbers if the benefits of loose rein management are to be maximized. One of Kelly Johnson's principles of management is: "The number of people having any connection with the project must be restricted in an almost vicious manner. Use a small number of good people (10 per cent to 25 per cent compared to the so-called normal systems)."

As the number of people under the direct supervision of the project manager grows, their requirements for communications and understanding one with another become much more complex. Because of this complication, the need for tighter control and more managerial direction also grows. McLean describes the problem in this fashion: "...as the working force passes the minimum number required and the rate of progress slows down, the perceived need for more people and more liaison increases rapidly. More engineers on the project can invent more avenues of approach and more techniques to try. The maintenance of coordination between all of these different possibilities becomes a function which again requires more people and more paper work. Competition for the available jobs becomes keen. Communications begin to fall off. The understanding of what is to be accomplished becomes more remote. The need for definite specifications becomes greater. And, finally, the ability of each engineer to participate in setting up the goals toward which he is working, and his contribution to the total design, become less, with a resulting loss of interest. Tension within such an overstaffed organization grows, mistakes become more common, the trying of new things which might lead to significant shortcuts becomes entirely too risky, and the designer eventually loses control of the organization. On the other hand, the closeness of a small organization stimulates continuous and rapid feedback between all the stages of the design process. Such feedback, provided by direct and rapid communication, is essential if we are to achieve integrated and functional designs. A small, effective organization can probably produce designs that are simpler and more reliable by factors of from 10 to 100 over the kind of equipment that results from the straight-line process of starting with the military requirement, building up a big organization, and wading through countless, detailed specifications."[3]

Not only is this a conclusion which project managers who were interviewed would accept, but all of them have records which prove the case.

<u>The size of the customer's office needs also to be held small, or relationships between the customer's program office and the project manager's staff kept to a minimum, or both</u>. If this is not done two conditions will evolve. First, upwards of thirty or forty people will be attending meetings. Second, the proliferation of government people responsible for project supervision results in the need for a corresponding man from industry. This is necessary simply to have someone for the customer's

[3] <u>Op. cit.</u>, p. 6. This point has also been made by others. See, for example, Richard B. Kershner, "The Size of Research and Engineering Teams," in <u>Eleventh National Conference on the Administration of Research</u>, State College, Pennsylvania, Pennsylvania State University Press, 1957.

representative to talk to at his level and communicate in his nomenclature and jargon.

The project manager must select staff having required competence and capable of operating as part of a project team. Project managers, like everyone else in organized effort, seek the best competence they can get for the job. But they select people through their own personal knowledge of capabilities and in this way are more certain of the way in which the team is likely to perform. Of course, it is not always possible to employ first choices, but the successful project managers apparently have a high degree of success in inducing the people they prefer to work on the team.

Not only is selection important so far as the immediate staff of the project director is concerned, but it may be cruicial in the selection of sub-program managers, or those working on the project in the functional areas. Dr. Cleghorn, for example, describes good sub-program managers "as those who have a strong dual loyalty--functional and project." He says his project people and the functional people on Orbiting Geophysical Observatory were not fighting each other because he selected sub-program managers of maturity who were able to live with dual loyalties and conflicts.

The project manager must try to assure the continuity of his project team, but be conscious of need for different capability mix as the project proceeds. Advantages of continuity in holding a first-rate team together are apparent. However, as the project moves from the research end of the spectrum to production, a different mix of talents is required. Project managers must be aware of the subtle change in requirements as work proceeds.

The most successful project managers, as viewed from the limited perspective of this study, apparently were able to alter their own managerial styles as the project moved across this spectrum.

Best results are achieved when the team that builds a satellite is integrated with the team that launches it. For weapons, a corresponding principle will be presented below under engineering. It seems obvious that launching a satellite is likely to be more successful if the team that built it participates, appropriately of course, in the launch. Not only should launch problems be reduced, but needed corrections in the "bird" for launch purposes should be clearer and more readily incorporated in succeeding models.

A project manager should try to upgrade his personnel. Kelly Johnson feels strongly that he not only has an obligation to upgrade his people but that they should try to upgrade themselves and in doing so advance their own as well as the interests of the project. His performance rating system in the "Skunk Works" is designed to help people upgrade themselves. It also results in keeping his team small, since he need not always add new engineers if a new skill is required. He feels that one of the reasons he can get higher productivity from his staff is that they spend time working with hardware so they can see quickly and directly the impact of what they design. The cycle from design to design change is immensely speeded in this fashion.

Planning and Control

Every project manager interviewed expressed a comparable philosophy about participation in design specifications and the need for a specific and concrete project plan. Everyone also had firm and tight control over every important element of his operation. While the project manager may have had a loose rein from his customer, he exercised a tight rein over his suppliers and staff, especially as the project moved into development and production. These systems varied much. Not one was found to be the same.

This is quite understandable, for planning and control requirements vary depending upon the particular phase of the research and development cycle, the nature of the project, its size, the environment in which it is placed, and the particular style of the project manager.

<u>The project manager should verify requirements and participate in the design of the project</u>. Every one of the project managers interviewed felt strongly about this principle. Verification of requirement, for example, has a major influence on project development in two fundamental ways. First, the requirement may be misleading and if not clarified may misdirect the research and development effort. McLean describes a case in point in these words: "In cases where the designer does work from stated specifications, they can quite often be very misleading. During the Korean War an urgent requirement was received for an antitank warhead capable of penetrating 11 inches of armor. Since we knew that it would be impossible to fire perpendicular to the armor under all circumstances, we took a nominal value of 60 degrees for the obliquity of penetration and designed a shaped-charge warhead capable of punching a hole through 18 inches of armor. This weapon was delivered to the operating services in great haste. Some of us became curious as to the motive power employed by Russian tanks that would enable them to run around over rough terrain carrying armor 11 inches thick. Upon investigation, we found that the actual armor of the tanks had a thickness of somewhere between three and four inches, and that the specification given us had resulted from the correction for obliquity having been made twice before, while the specification was coming through channels. It is this type of well-meant distortion that makes it essential for the designer to question his specifications and to go back to primary sources in order to develop a real understanding of his problem and the basis for the need, if

he is to create a successful product."[4/]

Second, verification of reliably stated requirements is important to define the problem and its dimensions. Indeed, Wilson of NOTS feels that a major control principle is that of "verification of requirement." He pointed out, for example, that he had received a requirement for a shore bombardment missile. The requirement specified range as well as other essential characteristics. Since the distance specified was the absolute maximum dictated by natural laws, he said it was important, for example, to determine just what range meant and how much could be sacrificed for other specifications. How much in distance? How much in trajectory? There were hundreds of other questions that should be asked about this and other characteristics before work begins. This is necessary, says Wilson, before the project manager can discover what technical problems must be solved.

One of Kelly Johnson's principles of effective loose rein management is: "The specifications applying to the project must be agreed to in advance of contracting. Be sure there is mutual understanding in this field before proceeding; otherwise, it takes a mammoth contracting department to unscramble the mess that normally develops."

Specifications should be detailed and the customer as well as the project manager should understand what each is and is not going to do. The very essence of loose rein management is the freedom to develop design on the basis of acceptable performance specifications established in advance. All project managers interviewed had some freedom in the development of design. As noted elsewhere, the project managers interviewed were not reluctant to assert that their freedom in design against specifications permitted the development of an end-product at lesser cost, better time,

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[4/] *Op. cit.*, p. 4.

and higher technical perfection than would otherwise have occurred.

The reasons for this are many. One is, as noted before, that when people have freedom to investigate and explore there is likely to be greater imagination employed and a higher degree of creativity encouraged. Also, the greater the degree of decision on the basis of communications in formal memoranda and reports, the less likely are new and imaginative ideas to be encouraged. As McLean puts it: "The more novel the idea, the fewer will be the people with the background to understand it, and the more difficult is the transferring of information about it without the question-and-answer process. Our present management technique for the approval of funds, which involves review of written proposals with many checkpoints in series, is almost certain to weed out those novel proposals that might constitute major advancements."[5/]

Another project manager observed that there was little question in his mind that his product was much superior to what it otherwise would have been because the customer was not invited and did not participate in early reviews of the design stage. During this stage, he said, there were many "in-house" battles. During these engagements the discussion was open and free. If the customer had been there, it is hardly likely that discussions would have been as open and objective as they turned out to be. He feels that today the customer is too willing to lend his hand in design and that the result is the customer helps more than he should. This particular project manager felt that the result was more likely to delay than to accelerate events, a feeling shared by most project managers interviewed.

<u>The primary control device of the project manager is the project plan and competent staff</u>. The importance of competent staff needs no further

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[5/] <u>Op. cit.</u>, p. 2.

explanation. Fundamental in the philosophy and practice of project managers interviewed, especially those in the development stage, is the need for an overall project plan. It should clearly specify in written form, and in detail, such elements as basic policy, description of the project hardware design, chief tasks to be accomplished, authority of the staff, milestones to be met, major interfaces, methods of control, subcontracting procedures, and procedures to follow in the event of a conflict between functional areas and between functional and project management areas.

One of the characteristics of successful loose rein project management is the thoroughness with which the project plan is developed and the firmness with which appropriate control devices are employed. This is not meant to imply any inflexibility in implementing the plan. Quite the contrary, a major characteristic of projects examined was their flexibility in adjusting to new conditions. Rather, what is meant here is that project managers had well-designed planning and control systems and methods which they applied with firmness.

The accompanying "Project Planning Matrix" portrays the type of planning tasks which should be spelled out and the variety of plans required in project management. The degree of detail required varies, of course, from task to task and plan to plan. Also, the timing of completion or development of firm numbers and detail varies from task to task and plan to plan. For example, plans for disbanding the project team upon termination are hardly as urgent at the beginning of a project as organizing the team in the first place to design the hardware. This matrix is included only to illustrate a grid to be filled and does not presume to imply any degrees of completeness for any one area.

The following discussion is not an attempt to describe all important

PROJECT PLANNING MATRIX

Types of Plans

Planning Tasks	Project Definition	Project Operating Plan	Contingency Plan	Project Expansion or Contraction Plan	Project Termination Plan
Organizing Project Team					
Developing Project Design					
Defining Work Tasks					
Scheduling					
Engineering Drawing Procedure					
Budgeting and Cost Control					
Profit Plan					
Quality Control					
Staff Organization					
Subcontracting					
Facilities					
Reporting to Customer					
Internal Informational Reports					
Project Expansion					
Project Completion					

planning and control principles and practices. Only the major ones derived from the interviews are presented.

Scheduled Staff Meetings

Scheduled staff meetings is a primary planning and control device. All project managers felt scheduled meeting are indispensable to effective management and high project performance. One project manager holds a meeting with his "high command" at 7:30 a.m. each morning. Weekly meetings with staff and monthly meetings with customers is a more general pattern.

At these meetings the project manager explores the entire range of problems concerning the project. Special periodic meetings are frequently scheduled by project managers to examine particular parts of their programs. Kelly Johnson, for example, observes: "There must be a monthly cost review covering not only what has been spent and committed, but also projected costs to the conclusion of the program." He advises, "Don't have the books ninety days late, and don't surprise the customer with sudden overruns."

The project manager should be abreast of developments in the critical areas of his program and formulate methods to anticipate problems. Every element of planning has a corresponding control phase. But some of the planned events have much greater significance to the project manager than others. These, of course, will receive most of his attention. By and large, however, his attention is focused principally upon technical problems, meeting scheduled events, subcontracting, producing within contemplated costs, and quality of product. Each of these problem areas will be discussed.

PERT/Time and PERT/Cost and Scheduling Tools

Most but not all project managers used PERT (Program Evaluation and Review Technique) in some fashion but none used it in precisely the same

PLANNING & CONTROL SYSTEM ELEMENTS

WORK BKDWN STRUCTURE/ PRICING/COST ACCT'G/NETWORKING

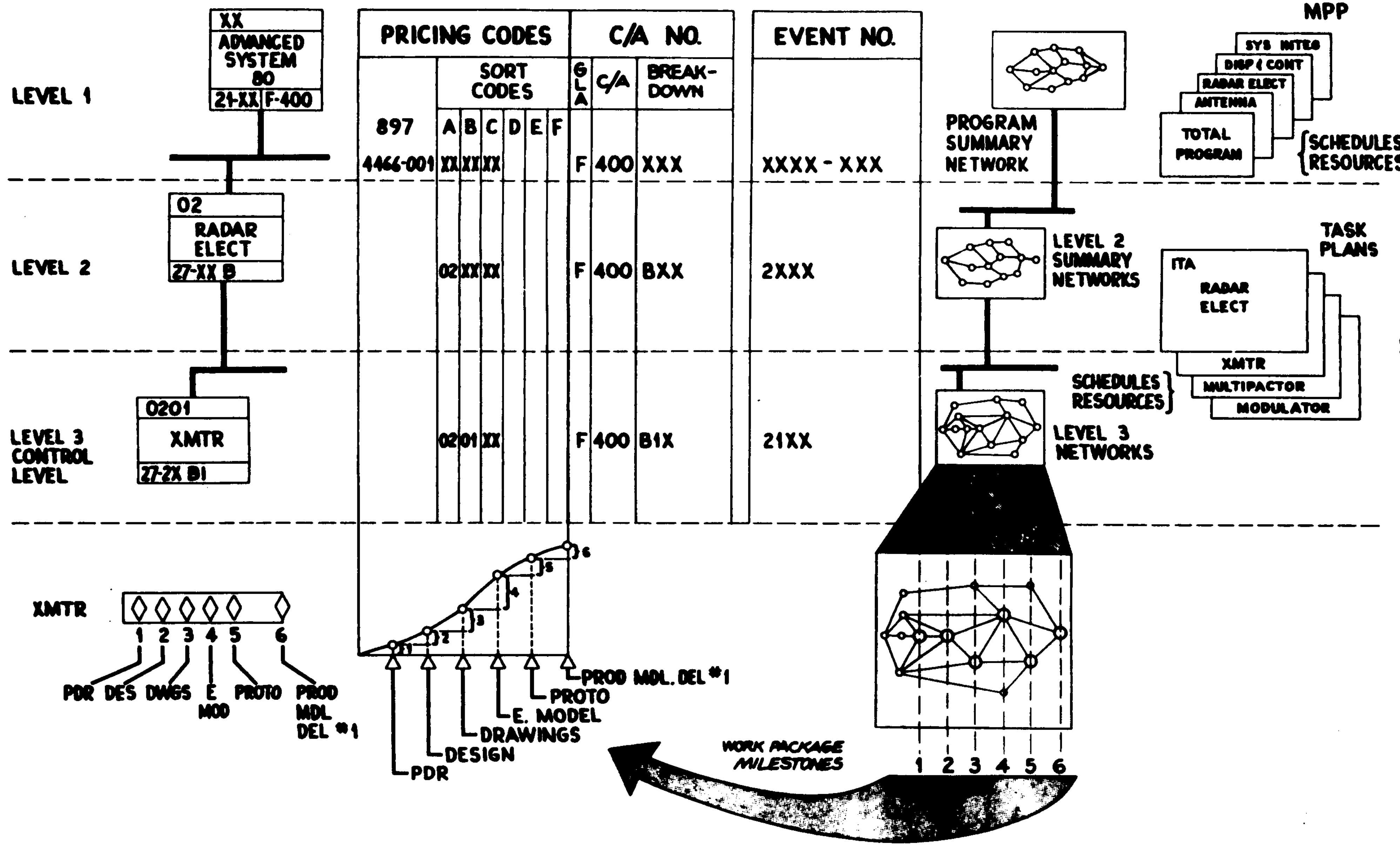

FIGURE 1

Reproduced with permission.

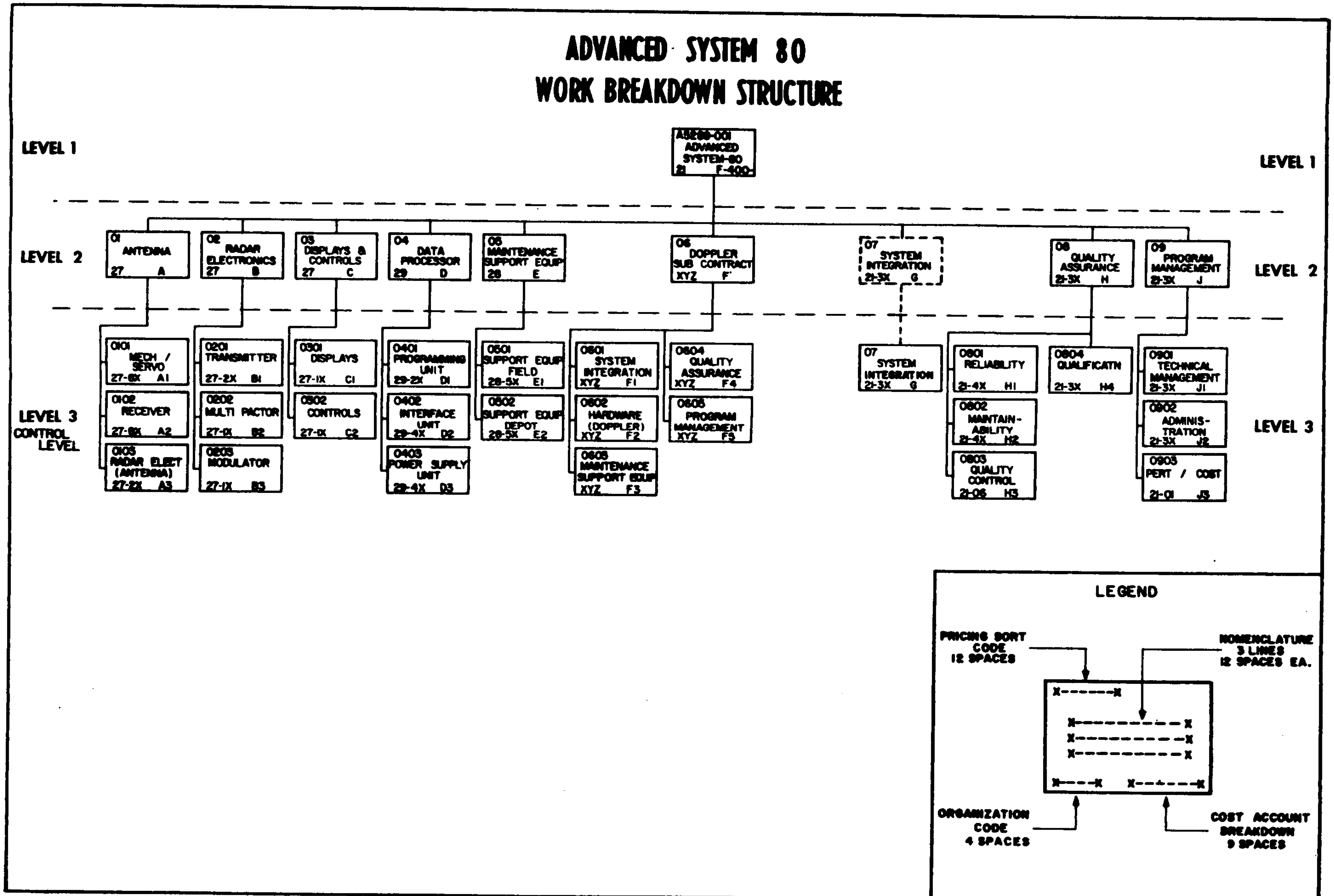

FIGURE 2

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This system has great advantages. It, for example, provides a comprehensive and clear framework for developing plans. It also provides a basis for improved management control by permitting direct comparison of proposed costs against actual costs. It also permits computer handling of data files by specifying separate modules which can be integrated in many different runs. Data processing operations are, therefore, more flexible and economical.

Control units are described in the work breakdown structure illustrated in Figure 2. These are the smallest units for which calendar forecasts, network, and other planning and control details are maintained in the system. All cost account numbers, funding systems, schedules, resource plans and PERT networks are tied to this unit. As a consequence, these pieces of information can be related to each other and readily summarized.

Program managers choose the control units in cooperation with supporting divisions. The choice, naturally, depends upon the size and complexity of the program.

All major reporting documents are prepared from computers. Periodic alterations in and print outs of the work breakdown structure and PERT/Time networks are easily made. A major control document also periodically prepared is the traditional milestone chart. A fourth basic control document is the cost of work report. On this report the following data are shown in chart and table form: actual and budgeted costs to date, projected actual and budgeted costs to completion, and the estimated "value" of work performed. Value, following the DoD and NASA PERT/Cost Guide, relates physical accomplishment against dollar cost. When a work package is completed, the value is equal to the original cost estimate, irrespective of actual cost. When a work package is in process, value expresses the dollar worth of work done in terms of time. If the original estimate for completing the work package is $15,000, for example, and $6,000 is actually spent as of today, but $18,000 (rather than $15,000) is now the estimated cost to completion, it is clear the work is today only one-third finished. Value is, therefore, one-third the original estimate, or $5,000.

Project managers adapted PERT to their needs. This is well illustrated in one project where the launch date was firmly fixed by planetary conditions. For one space probe the project had a "28-day window." If the vehicle was not ready during that time, it could not be launched for a long period of time. The project manager, therefore, scheduled all sub-events and activities from this point in time. He worked backwards rather than forward. This system he jokingly referred to as "TREP"!

Reporting

Formal reporting both to the customer and internally to the project manager should be limited to the minimum information required, and important work should be recorded thoroughly. Both the customer and the project manager have need for written reports, but if reporting requirements are not watched carefully they can easily become excessive. The customer has obvious needs for reports to answer such questions as: will delivery of major components and the finished product be on time? Will the costs of the project be in line with plans? Will the product perform as required? Basic reporting requirements of the project manager have been noted previously and need not be repeated here.

Most project managers interviewed on this matter felt the importance of avoiding unnecessary reporting simply as a measure to reduce costs by eliminating useless work. One project manager asserted that formal reports to the customer on a weapon system comparable to his, but tightly controlled, was forty times his number of reports!

Project managers should make full and complete reports on important events and problems. Reports should not be mere accumulations of miscellaneous documents but should be carefully prepared in depth to meet the informational needs of the customer. Unnecessary surprises should be avoided. This can be done by frank and open disclosure of major problems. As will be noted later, mutual trust between the customer and the contractor is a central pillar in loose rein management. If reports do not tell the customer what he needs to know, even though the number of reports is kept at a minimum, "dis" will replace "mutual" in the "trust" pillar.

Quality Control

A simple yet highly effective quality control system must be installed. All project managers were deeply concerned with quality control and had developed different yet effective methods to assure required performance of both components and the end product.

Kelly Johnson, for example, pushes basic inspection of components back to vendors. He refuses to pay for components that will not work and he seeks to avoid wherever possible duplicating inspection.

One of Kelly Johnson's principles is that: "The contractor must be delegated the authority to test his final product in flight, without being over-run by the customer." He feels that: "If he has brains enough to design and build a vehicle, he certainly can and must test it in the initial stages. If he does not, he rapidly loses his competency to design other vehicles." He feels he cannot do his job if he does not know how the machine works. "There must be mutual trust in testing," he says.

Testing an airplane is somewhat different from testing a new space satellite. Project managers, however, must be intimately involved with the customer in testing to assure the technical feedback necessary in further development.

Project managers have developed different methods to recognize "error signals" in components. Colonel Westmoreland, for example, tried to forecast trouble spots by developing reliability studies and failure mode analysis. He sought systematically to develop reliability ratings for components. If one component had a reliability rating lower than another it could be a possible source of trouble. His failure mode analysis was a method to help explain what would happen to a system if a particular component failed. In considering each component he asked the question: In consideration of the state of the art, what are the possibilities of failure and what will be the impact on the system as a whole?

Cost Control

The project manager should control his costs through controlling competency and size of staff, simplified design, frequent cost reviews, meeting scheduled milestones, making prompt evaluation of engineering change proposals to determine whether they are necessary or only "gold plate," and securing quick decisions on engineering change proposals from the customer. Comments have been made about most of these areas of control. Those not discussed previously will be treated in subsequent pages.

Cost control by the project manager obviously is not based on a single or a few elements. It is a composite of actions involving a broad band of managerial art and science. But the principle stated here is useful because it focuses attention on major elements of control.

Subcontracting

The project manager must have major responsibility in determining subcontractors and must consider selection to be highly important. Of dominant importance in make-or-buy decisions is assurance of maximum quality at minimum cost and timely delivery. Wherever possible, the prime contractor should have multiple sources. The project manager must have, himself, or find in his organization, as much technical capability as the subcontractor.

When we were examining the role of subcontracting in the development of prototypes, we were struck by an apparent contradiction. Project managers who wanted loose control for themselves did not control their subcontractors loosely. They gave them tight design specifications, and where these were impossible or difficult to prepare, wrote as definite performance specifications as they could. They showed a great preference for competitively bid, fixed-price subcontracts.

This behavior, however, is entirely rational and compatible with loose control. It does not present a paradox. Instead it is the result of the project manager's rational attempts to control for himself the major portion of the uncertainty relating to the project by the process of elimination; that is, he subcontracts for those components of the prototype which have less uncertainty of accomplishment associated with them.

A prototype is not a unitary object. It is a carefully assembled collection of components, some old, some new. These range from standard items of procurement, such as bolts and fasteners which may be purchased on the open market, to innovations such as a new guidance system which no one has ever built or tried to build. Before commencing work, the contractor must "break out" the design into components. This is done to identify those components the firm should build and those it should subcontract.

Tight control of the suppliers is clearly possible if there is less uncertainty of accomplishment connected with the subcontracted components. These components are already in existence or their construction is predictable. Thus, the supplier can be held to account for his methods and results without the possibility that the component he delivers will fail to perform to specifications.

Components built under the direct control of the project manager are usually those which push the state of the art, are untested, or have never before been fabricated in precisely the fashion proposed. A large part of the success or failure of the development rests on the performance of these components, for they embody the novelties of the prototype. The major mechanism for sorting components is the make-or-buy decision sequence. A brief review of its major factors is appropriate here.

First, are the government's desires. These cannot be quantified. ASPR requires only that a firm subcontract for parts it can buy more cheaply than build. (Costs and pricing as a discrete factor of the decision-making process will be considered later.) Although there are no stated requirements of the amount of subcontracting desired, contracts are awarded to firms who have planned an optimum amount of subcontracting. This optimum is nowhere expressed in regulations, guides, or directives, so the firm must first infer what the optimum is at the time of bidding.

Second, after the firm has decided on the general level for subcontracting effort, the next factor considered is company policy, e.g., an electronics firm might not <u>want</u> to build an airframe. If policy precludes making the item, it is subcontracted.

The third factor is the degree to which the item can be specified or described. At one end of the spectrum are "off the shelf" items which must be purchased. Near the other end are components for which design specifications cannot be prepared and for which only very general performance specifications exist. The greater the precision by which performance, design, test, and evaluation can be specified, the greater the likelihood of successful subcontracting, hence the greater the pressure to subcontract.

The fourth factor is the skill inventory of the firm, that is, does it have the engineering and other skills to design and build the item? If not, it must buy it, provided that the needed skills do exist outside the firm.

The fifth factor is capacity. Does the firm have unused or under-employed technical skills, workers, and equipment? If not, there are strong pressures to purchase the component.

Sixth and last, price and cost comparisons must be made for the components which have survived the screening provided by the first five factors. As we have said, ASPR requires the item to be purchased if that is cheaper than building it.

The above process is iterative. It can be and is repeated. Before award, it may be recycled if the proportion to be subcontracted varies from the amount the firm conceives to be the optimum. After the award, it may be repeated if there are changes in technology, internal or external capacity, new discoveries, or any such changes in the environment in which the decision must be made.

The following table is a capsule description of the make-or-buy decision-making process.

THE MAKE-OR-BUY DECISION

Factor No.	Brief Title	Consideration	Decision
I	Government interest	Weak Strong	Low per cent High per cent
II	Company policy to manufacture item	Yes No	Make Buy
III	Precision of description	Low High	Make Buy
IV	Skill inventory	Available Not available	Make Buy
V	Capacity	Not filled Filled	Make Buy
VI	Cost to make	Lower Higher	Make Buy

Note: This process may be recycled at any point if (a) the total per cent subcontracted is not optimum, or (b) there are changes in the decision environment.

The chief result of the make-or-buy decision-making process is to retain under the direct control of the project manager those components that cannot be described or costed exactly, and for which the firm has suitable skills, technology, and capacity available to produce. These are items whose production entails substantial uncertainty, but where the probability that this uncertainty can be overcome resides "in-house." Items subcontracted tend to be those for which clear specifications and tests can be developed, so that fairly rigid control can be exercised over the subcontractor. Thus, it is the character of the work that is subcontracted that determines the type of control, rather than the whim of the project manager, and tight control of supplier is not a contradiction in philosophies.

It seems obvious to us that the project manager should participate in source selection as well as in the make-or-buy decision, yet many of the project managers we interviewed stated that they had not so participated.

We recognize that in many instances source selection precedes contract award and the appointment of a project manager. Whenever possible, it is highly desirable that the project manager have a voice in source selection since he will be ultimately responsible for the performance of subcontractors.

A project manager should have, if possible, two or more sources for component and other subcontracted work. This is important because it assures a competitive technology and price. Single sources may price considerably higher than when faced with qualified competition.

Project managers need technical capability equal to that of the subcontractors. This is an obvious requirement if the suitability of the results of the subcontracted work is to be properly determined. Of great importancc, too, is this ability if the subcontractor gets into trouble. The project manager must do something about such problems and is in a better position to determine what should be done if he has the right technical ability.

Control of Funds

The project manager, especially one working in a matrix organization, must have control over funds made available for the project. The typical project manager prepares budgets for operations. Performance is partly measured by conformance to budgeted expenditures. There is no question about the fact that authority of the project manager in a matrix organization needs to be buttressed with control over funds.

Engineering

The project manager should be his own chief engineer and be willing to trust his own judgment in making decisions with a high technical content. Project managers must be chief engineers with high capability. Sampson feels that the quality which has made for his greatest success is his competence in many technical fields. He can understand and talk to men in many different disciplines and, when the occasions require, is ready to make technical decisions across a wide spectrum.

Kelly Johnson points out that 65 per cent of his working time is spent on technical decisions, and as a consequence he is not and cannot be a mere managerial coordinator.

Throughout the development of a project all sorts of trade-off problems arise. The project manager is in the best position to view the entire system in making these decisions. One problem with subordinate engineers, for example, is that as the final day of delivery or test approaches, there is a tendency for them to be self-protective. Colonel Westmoreland observed that, "Not only are they functionally oriented, and try to do the last little bit of engineering [commonly called "Gold Plating"], but they try to keep themselves covered, i.e., to lessen the risks they take even if this means increasing cost and time. Thus, the project manager must be prepared to make decisions against staff advice."

Technical competence also is, of course, important in the customer's project office. One project director illustrated this in the following case. A month before launch on one of his projects a fairing problem developed. The system to disconnect the fairing after launch had failed in test. The project director told the project manager to try primer cord for the explosive charge. Engineers of the contractor wanted many tests before approving this change. The project director had no money for these tests and permitted the contractor but one. The test was satisfactory and the launch successful. Here was a tough problem of judgment. The project director felt that the company engineers did not see all facets of the problem. They were more concerned with preventing failure than with launch time and cost. The project director had the over-all view. He wanted no failure but also knew how critical was his keeping to project schedule and allocated cost. In deciding, he had to take many risks. Engineers of the contractor, he felt, did not want to take risks. To eliminate risk, of course, requires more time and money. The project director, however, was willing to decide the point of trade-off between time and cost on the one hand and risk of failure on the other. In this particular case, if the project director had gone to higher authority for decision the launch probably would not have been made on schedule. So, he took an additional personal risk of reprimand if the launch failed.

The project manager must not become embroiled in all technical matters. If he does, he will not have time to get to other problems. It is important, therefore, for him to distinguish among those technical matters he is required to understand and act upon.

Carlson says that the project manager must be astute enough technically to "smell out" and correct technical problems. Technical difficulties cost money to solve. The project manager must be able to anticipate problems; otherwise, he is only a reviewer of the passing scene. Carlson notes, too, that engineers often shield problems, inadvertently or purposefully. "They can get so engrossed in their problems," he says, "and excited about the challenges that they fail to fit the difficulty of solution into the schedule and configuration design of the system as a whole." The project manager must, therefore, be able to "smell" technical problems which might not come to the fore readily.

"But," says Strauss, "engineering is not the prime job of the project manager. He must consider the totality of his job. He has problems of manufacturing, service, dealing with the customer, as well as engineering.

He cannot isolate the engineering problem. But he must be able to handle the engineering problem."

One of Kelly Johnson's principles, which fits our model at this point, is: A very simple drawing and drawing release system with great flexibility for making changes must be provided. Johnson observes that typically the flow of drawings from the fellow that makes them to the fellow that finally makes the piece of hardware is very complex. It is complex to be sure that no one makes an important mistake. He feels, however, that this system can be much simpler. He has cut drawing release time to a minimum, has eliminated a great amount of typical procedure for drawings, and insists that his engineers see the whole system and not just a small, minute part of the total system.

Reducing the number of drawings and drawing time is of major importance in cutting time and cost to prototype. Furthermore, it is a fundamental method of control. Wilson points out that, "When a project manager loses control of drawing changes, he loses control of his project." In this, however, he must work closely with the customer. It is clear that an ability and willingness on the part of the customer to approve drawing changes promptly is an indispensable support to the project manager in cutting time and cost.

On the Vela Hotel, for example, the U.S. Air Force System Program Officer, Colonel Westmoreland, made it a point to make quick decisions on drawing changes. In addition, he sought to reduce engineering drawings by allowing changes to accumulate before a drawing was redone. He points out that as projects get larger it is less likely that operations can be this loose. There must be more formal configuration control. But for smaller projects the principle specified above is applicable and can cut time and tion (which includes a specified drawing release system), control of contract specifications, and the processing of engineering changes.

One of the purposes of configuration management is the production of engineering drawings which contain detailed production specifications (commonly referred to as "build-to drawings") to give uniformity in production[6/] rather than primarily supporting the development project.

Most project managers must follow this production-oriented technique, for the majority of contracts contain a requirement to follow the prescriptions of configuration management. Some, however, can apparently resist its application.

Colonel Lonnie Westmoreland stated that he told his superiors that he could only apply configuration management if his office were staffed with the additional people needed to supervise its application. For budgetary reasons, these persons were not assigned to his office. To a large extent, this accounts for the ease with which changes on the Vela Hotel project, referred to above, were approved and documented.

Customer Relations

Mutual trust must exist between the customer's organization and the project manager and be nurtured with close cooperation and liaison on a day-to-day basis. Carlson says flatly that, "Every successful project manager has good relations with his customer. Every unsuccessful project manager has bad relations with his customer." Developing and maintaining relations in which mutual trust is a keystone in the arch is, therefore, most important for both the customer and the project manager.

[6/] Air Force Systems Command Manual 375-3, System Program Office Manual, 15 June 1964, p. 39.

The project manager can and must build confidence in many different ways. For example, he must minimize overruns; minimize failures; maintain schedule; be realistic in future estimates of costs, time, and quality; prepare sophisticated plans and be able to implement them with a maximum of efficiency; show recognition of the customer's viewpoints; and in general make it clear that he is a first-rate project manager and has high technical capability.

On the other hand, the customer's project officers must also be willing to foster an attitude of mutual trust and take actions which rely upon its existence. For example, as will be discussed later, the project officer must be willing to make quick decisions where appropriate, understand the contractor's position, and genuinely attempt to foster mutual understanding and trust. If contract management personnel of the customer insist on distrusting contractor motives, an attitude and atmosphere of trust is naturally precluded.

There is no necessary conflict between the interests of the customer and the contractor which inhibits mutual trust. As Baumgartner points out: "In negotiations leading to a contract or modification, the project manager's duty is one of strongly supporting the company's position, which presumably is one involving hard, determined bargaining with the customer. Upon reaching a contractual agreement, however, whether it is favorable or unfavorable to the view that he supported prior to the understanding, he is the trustee for the customer. He has had his day of dissent. From then on, whether popular or unpopular with his company, his duty is to discharge his trust to the best of his ability. His company's future business may well depend on his performance and the reputation that thus accrues to the company, for better or worse."[7] This is a philosophy with which all project managers interviewed would agree.

Baumgartner also observes an hypothesis worth testing. "It is probable," he says, "that [customer] surveillance varies inversely with customer confidence. The greater the confidence, the less surveillance. The project manager who takes steps to maintain the customer's confidence will be freer to run his own show."[8]

Mutual trust must be forged with subcontractors. One subcontractor interviewed made this observation about his dealings with William Chalmers. "I never met Mr. Chalmers," he said. "My contacts were with engineers who had cognizance of certain aspects such as quality control and reliability, and these contacts were held to a minimum. There were, I believe, four design review inspections held at various stages of the contract. Both I and Space Technology Laboratories knew what was wanted and evaluated the design and manufacturing on the basis of requirements. There was an atmosphere of mutual trust. For example, they would agree on circuit designs or circuit specifications yet they felt it was not necessary to take the time or effort to reduce this agreement to writing. I feel it takes far too long to get these agreements in final writing, and that it is not worth the time it takes to do this. We can get the engineers to agree to a circuit on the blackboard within a few hours, but it would take many days to reduce this agreement to writing. The principle here seems to be that if you are to reduce time, you must first have your program supervision competent to evaluate the customer's proposals, and second, have an atmosphere of mutual

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[7] John Stanley Baumgartner, Project Management (Homewood, Illinois: Richard D. Irwin, Inc., 1963) pp. 126-127.

[8] Ibid., p. 130.

trust."

Every effort must be made to hold the size of the project offices small, in both the customer and contractor organizations, or to assure that specific personnel contacts between the two are small in number.

When numbers of people in project offices of the customer grow in numbers it is necessary, as noted previously, for the contractor's team to add people to deal with them. To the extent such contacts can be reduced, and still avoid unnecessary inefficiencies, costs will be cut.

An associated principle of understaffing would, we think, be accepted by our "typical" project manager. It is: Under-staffing is preferred to over-staffing and small groups are more efficient than large groups for research and development.

If reduction of staff, however, results in delayed decision, just the reverse may occur. For small staffs to facilitate rather than hinder achievement of project objectives it is important that they be strong in the sense of technical and managerial capability, and in a willingness to decide as promptly as possible. Personnel in both customer and contractor project offices should be willing to make decisions as promptly as possible.

The project manager and the customer must recognize and agree on a hierarchy of decisions: those made by the project office of which the customer need not be aware, those made by the project office of which the customer must be informed, those in which the customer must participate, and those made by the customer. If decisions are to be made promptly, there must be understanding about which decisions are to be made by whom. Without this understanding, the result inevitably will be delay and confusion as well as increases in cost and time.

But another element is essential. It is a willingness on the part of both the customer's project officer and the contractor's project manager to make decisions. Not only may red tape and procedures inhibit decision-making, but fears of failure and jeopardy to career may weaken the resolve of strong men. One project director who was not afraid to make decisions, an attribute which the project manager asserted was a major cause of his success, illustrated the problem this way: "Once a launch was approved with at least three minor defects. Had the launch failed my judgment would have been severely questioned." This probably is an underestimate of what might have happened to him!

One of the great advantages of prompt decision-making in the project office is that the project manager may feel free also to move promptly. One project manager who was blessed with a project officer not afraid to decide pointed out that his own contract office kept insisting that the project manager was out "on a limb" because he did not have written approval for the action taken. The project manager pointed out, however, that he had always been able to trust the word of the project officer and until such time as he had occasion not to do so, he was going to continue to trust his word and let the paper follow the decision and not delay action.

Staff Relationships

This is an area of broad scope, the full dimensions of which clearly were not covered in our interviews. In previous sections of this Report, a number of observations were made concerning staff. Only selected additional observations on staff are therefore presented here.

The project manager must encourage the flow of problems to him, must be willing to tackle problems at any level, but must be selective in deciding which problems to resolve. As noted previously, most project managers have periodic daily or weekly meetings to discuss problems with staff. But one project manager encouraged anyone working on the project to come directly to him with a problem. Anyone concerned with even the smallest problem was encouraged to come directly to him and not feel obliged to go through intermediaries. This was done to make sure that those with problems would not be thwarted in bringing them to the attention of the project manager. This project manager pointed out that about 25 per cent of all problems that came to him in this way were significant and that about 20 per cent were very serious. He felt that if this open-door policy had not existed some of the seemingly small problems might have been neglected to the disadvantage of the entire operation.

The project manager must secure the loyalties of staff in the functional areas. The more successful project managers have the loyalties of workers in the functional areas in matrix organizations. One project manager reported that people in the functional areas frequently told him about things that were likely to happen in their areas before the event. Loyalties of people in the functional areas working for this man seemed to be stronger toward him than toward their supervisors in the functional areas. One of the reasons for this condition in this case seemed to be that the project manager helped the functional people to solve their problems. He worked intimately and carefully with them. He was able to instill in them a strong sense of participation in a successful, important, and dramatic program. He provided a mechanism for them to be identified with the object they worked on. They could see the results of their work. He said, "The functional (operating) divisions do not satisfy their needs. Identification with our program does."

Kelly Johnson has two operating principles which should be recorded here. Access by outsiders to the project and its personnel must be strictly controlled by appropriate security measures. The application of this principle, of course, relieves the project director and his staff from unnecessary and costly associations with people outside the project. The more dramatic the project, the more likely it is that more people not directly associated with the project will want to visit it.

Pay of personnel must be based upon performance and not the number of people supervised. If a project manager is successful in holding the number of personnel on his project to minimum numbers it is obviously important that their remuneration be based upon capability and not some irrelevant measure such as number of people supervised.

Contract

The contract should contain as clear and complete a work statement as possible, given the state of the art. An unequivocal set of requirements is a major asset in developing an operational plan. Misunderstandings, uncertainties, and conflicts are reduced in such contracts. While not all project managers interviewed had such tailored concrete foundations from which to work, they were conscious of its utility and sought for such contractual terms whenever possible and appropriate.

Where appropriate, the preferable form of contract contains incentive features. Where substantial uncertainty exists about technical feasibility and design, the fixed-price-incentive contract may be inappropriate. This is truer the closer the project is to the pure research end of the spectrum of the research and development horizon. The cost-plus-an-incentive-fee contract is more appropriate for development contracts with less technical, cost, and time uncertainty. Where appropriate, the fixed-price-incentive contract is a powerful motivator to excellence in performance at minimum cost and time.

Two developments concerning loose rein project management appeared in our investigations which, if continued, clearly negate its advantages. The first is that, despite incentive contractual arrangements, the customer's project officers continue to exercise surveillance and control applicable to non-incentive contracts. The second is a tendency for the customer's project officers to be less responsive in making decisions requested by and required for the contractor. One project manager complained in these words: "The Department of Defense is pushing fixed price contracts on producers, but some contracting administrative personnel still think in terms of CPFF controls. Others feel they have little responsibility. The contracting personnel in effect say, 'The problem is now that of the contractor. I can go play golf.' Contractors are having a tough time getting decisions. To change a fixed price contract almost takes an Act of Congress."

III

THE INCREASE IN CONTROL OF RESEARCH AND DEVELOPMENT CONTRACTS

In this chapter we wish merely to explore one aspect of the complex government-industry relationship which has a major bearing on the study. It is the increase in number and in specificity of the regulations by which government (as a powerful customer) controls the behavior of industry (the supplier). It is not intended that this chapter be a definitive study of growing regulations. It is fitting, however, to present a thumbnail sketch of this phenomenon as a backdrop for just the reverse--a loose rein management. While both detailed regulations and more loose rein projects could be approved at the same time, this has not been the case in recent years. Loose rein has declined while detailed regulations and tight rein have grown.

The relationship between government and industry cannot be described, understood, or administered as if it were a classical and simple case of a buyer and a seller. The government-industry connection is multi-dimensional, comprised of many aspects--financial, managerial, contractual, political, social, military, and economic. The changes in the procurement regulations reflect the increased complexity of these relationships.

Changes in this relationship are not well understood, nor do they clearly move in one direction. An effort to restore freedom in one dimension (perhaps the reduction of data demanded) may be rendered ineffectual by an attempt (perhaps by another agency) to prescribe methods to generate this same data. Since the government is not monolithic but is composed of many more or less independent agencies, directives from different sources may reflect differing policies.

Reasons for the Growth of Regulations

Clearly observable in recent months is a proliferation of regulations which apply to the procurement of research and development, and which are designed to prescribe more exactly the posture industry must take with its customers--the various government procurement agencies. These regulations have many purposes and goals. Many are not intended to apply directly to industry, but to subordinate organizations of the government agencies which supervise various aspects of the contractual relationship with industry. However, the net result has been to prescribe, in an increasingly precise fashion, the procedures and methods which a contractor must follow if he hopes to bid successfully, have his contract administered with minimal interference, and enhance his reputation to increase his future sales.

The changes in directives and guidance stem from three rather broad and laudable objectives. First, there is an increased desire on the part of government personnel to participate ever more deeply in decisions. Responsible parties in government agencies wish to take part in decisions to attempt to prevent industry from taking actions that may appear proper for one organization, but may have adverse effects for others, or to prevent inadequate attention being paid to the future effects of present actions. From this desire, for example, have stemmed requirements for ever-increasing amounts of information supplied by industry to the government. The needs of the procurement agencies to follow Congressional and executive legislation, orders, and wishes also, of course, demand much data.

Second, is a desire to stimulate a competitive environment. Government has long felt that its actions tended to create monopolies or captive industries which are more concerned with survival for their own sake than with cost reduction. There have been strenuous efforts by all government entities to increase the number of competitors at each stage of the procurement process (perhaps to prevent "buying in")[1/] and an increasing appeal to the profit motive of contractors through such devices as incentive contracts.

Third, is the external desire to reduce costs without impairment of schedule or downgrading of performance. Costs of military research and development have risen from $0.5 billion in 1945 to $6.6 billion in 1966.[2/] Not only do costs of this magnitude offer a fertile field for potential savings, but they become more "visible" to Congress, and strong Congressional pressures develop for agencies to justify expenses and to reduce those that the Congress feels are inappropriately high.

There have been in the past massive cost overruns and schedule slippages. Peck and Scherer, in their study of twelve weapons programs, found that the average development costs of these programs exceeded that estimated by 3.2 times.[3/] Marshall and Meckling, in a study quoted by Peck and Scherer,[4/] found that the average production costs of twenty-two Air Force projects exceeded that estimated by a factor of between 2.4 and 3.2, depending upon who made the adjustments needed to render the performance and the estimate comparable.

All of these substantial overruns cannot be ascribed to a lack of cost consciousness or poor management on the part of industry. Part of the

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1/ "Buying in" is an unrealistically low bid on a development project made in the hope of winning a follow-on production contract since the developer would, in effect, be the sole source.

2/ This is the budgeted item for Department of Defense Research, Development, Test, and Evaluation. Some research and development expenditures are also in the production accounts. Of course, other agencies, such as NASA, also have increased research and development expenditures in recent years.

3/ M. J. Peck and F. M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1962).

4/ Ibid.

responsibility for exceeding the original estimates must be borne by the government. First, the estimates may have been unreasonably low, yet were forced on the contractor for political or budgetary purposes. Second, cn all contracts there have been numerous changes, in specifications or design, initiated by the government while the work was in progress. These can substantially raise costs and extend schedules.

Since most contracts and work statements are classified, there has been no published study of the costs of contract changes, the reason for initiating these changes, or whether they were for the benefit of government or industry. Assistant Secretary of the Air Force, Leonard Marks, Jr., has stated that the Air Force Systems Command is currently making a study report on change management.[5/] This report is not yet available. It may not be completed. Until it is, it is premature to assess blame for cost overruns. It is unwise to charge either industry or government with poor cost discipline, and to increase control to improve such discipline, which may, in fact, not need improving.

There have also been concomitant changes in the procurement climate, two of which we believe especially significant. First, is the accelerating rate of technological growth. Space and defense products are now both larger and more complex, although they may have a shorter life in the sense that they may become obsolete sooner than in the past. This generates efforts to apply the findings of research as early as possible. In an effort to shorten the time of application, the government has shifted from its earlier position that innovation cannot be planned and controlled to a position that

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[5/] "The Challenge for Aerospace Management in the 1970's," a speech by The Honorable Leonard Marks, Jr., Assistant Secretary of the Air Force, Financial Management, at Los Angeles, California, May 12, 1965, p. 12.

it can and must be planned and controlled. Also, it has concluded that methods which were appropriate to the planning and monitoring of small development projects were not suitable for large, complex systems.

The second change in the procurement climate is the virtual abandonment of concurrency as a device to shorten the time to procure a weapon or space system. Concurrency means the concurrent development, test, and production of an end article or a system. This concept was not an unqualified success. For example, fine aircraft were delivered without power units to start them, test equipment to check their electronic gear, or enough trained crews to fly them. Instances were reported of drastic changes in production lines because of defects discovered in the concurrent test of the prototype. As a result, production contracts will not now be let before the basic technical requirements have been proven. Essentially, the government's position now is that a development's feasibility and producibility must be proved and documented before prototype development is commenced.[6]

In general, the government's response to these changes in goals and in climate has been to modify its relationship with its suppliers in many ways, but especially in the direction of increased control over the procedures followed by contractors in the procurement process. For purposes of the analysis of this study, three broad categories of government control should be examined. They are system management, program budgeting, and incentive contracting.

Of course, there are other categories, and there are many areas in which these overlap. Each of the above represents but one area of a broad effort on the part of the government to reduce the heavy costs of the space

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[6] Air Force Systems Command Manual 375-3, System Program Office Manual, 15 June 1964, p. 4.

and defense program. These categories are chosen for discussion because we can classify most of the efforts to increase controls under one of the three.

System Management

Over the past decade, it became increasingly apparent that the government's procurement process could not be described as the acquisition of individual items, such as an airplane, an engine, or an instrument. Rather, the government procures a function which can only be performed by a well-integrated system consisting of many articles and many skills. In many cases in the past, as noted above, insufficient attention to the need for integration of components of a system led to poor intermeshing of major parts of the system. System management was conceived as a formal device to insure that the planning and execution of this integration received early and sufficient attention. It has been defined as, "The process of planning, organizing, coordinating, controlling, and directing the combined efforts of Air Force contractors and participating organizations to accomplish system program objectives."[7]

Such a unified management has long been needed. Three approaches have been attempted: first, contracting for industry to perform this role; second, having it performed by a nonprofit organization such as the Aerospace Corporation; and lastly, having a government department perform system management for itself. The last approach is currently the most popular, for the government feels that it now has the management capabilities to manage systems. The present position of the United States Air Force, for example, is to perform system management itself. The Air Force can now be considered to be in the position of a prime contractor, actively managing the perfor-

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[7] Air Force Regulation 375-1, Management of System Programs, 25 Nov. 1963, p. 1.

mance of its contractors, integrating their activities and centralizing decisions at the proper level in the Air Force.[8/]

Reserving this function to the government is understandable, for a large system must be integrated into a force structure; that is, it must mesh with a larger complex of bases, people, and strategy. The obvious organization to accomplish this integration is the one that possesses sufficient information, authority, and ability to coordinate the required decisions. In nearly every instance this organization is a governmental department such as the Air Force.

System management is designed to insure that the diverse efforts of many contractors and agencies provide an integrated space or defense system, not a poorly meshing conglomerate of parts. Put in another way, its intention is to insure that all the effects of a decision, both in the future and in the present on other related but relatively independent projects in the system, receive proper consideration. Decisions are made at the level which possesses all the facts concerning the system. This tends to raise the level at which decisions are made.

System management antedates the introduction of program budgeting in the Department of Defense. But system management relates closely to program budgeting since both are concerned with the future effects of present decisions, both force the manager to consider the total costs and detailed schedule of a system and its interrelationship with competing and supporting systems, and both look toward the end product, output, or benefit of the system.

Our examples of growing controls reflecting the influence of system

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[8/] Air Force Regulation 375-1, op. cit., says, "Industry plays a major role, but responsibility for systems management rests with the Air Force...," p. 4.

management are drawn from the Air Force, for this service has developed this type of management more highly than the other agencies and services. Moreover, the Air Force's approach will probably be officially adopted by the Department of Defense. Much of the present Department of Defense policy originated within the Air Force. For example, it is interesting to compare Department of Defense Directives 3200.9, Contract Definition, and 5010.4, System/Project Management, with the earlier Air Force Regulations of the 375 series, and Department of Defense Directive 5010.2 with Air Force Regulation 310.1. Air Force procedures and policies are embedded and embodied in the Department of Defense Directives.

The massive nature of the regulations surrounding a research and development contractor is nowhere better illustrated than by referring to the Air Force directives concerning system management. The original Air Force Regulation 375-1 was expanded on 25 November 1963 into five separate regulations, each concerned with a major aspect of system management. They are: Air Force Regulation (AFR) 375-1, Management of System Programs; AFR 375-2, System Program Office (SPO); AFR 375-3, System Program Director (SPD); AFR 375-4, System Program Documentation; and AFR 375-5, Definition Phase of System Life Cycle.

Within the last eighteen months, the System Command of the Air Force has written and published five very detailed manuals, each designed to amplify or explain a major area of system management. They are: Air Force Systems Command Manual (AFSCM) 375-1, Configuration Management; AFSCM 375-3, System Program Office Manual; AFSCM 375-4, System Program Management Manual; AFSCM 375-5, System Engineering--Management Procedures; and AFSCM 375-6, Development Engineering.

A contractor must be familiar with these regulations and manuals. He must also know Air Force Manual 310.1, Data Management, since it prescribes the type and amount of data which a contractor must produce or provide for each type of contract.

The Department of Defense (DOD) directives are few, short, and generally broad in scope. The Air Force Manuals which now implement these directives would occupy a bookshelf. The Armed Services Procurement Regulations (ASPR), which in part describe how these policies will be incorporated into contracts, comprise over 1600 pages of text and 800 pages of appendices. The ASPR's have been revised thirteen times since 1963. The Air Force Procurement Instructions which qualify the provisions of the ASPR for the Air Force have a volume equal to the ASPR and have been revised fifty-four times in the same period. The situation in other procuring agencies--NASA, Army, and Navy--is similar although perhaps the volume of directives is not as great.

The proliferation of these regulations has been so sudden, and they have been so poorly understood, that the Air Force has printed two semi-official instructional books, together known as the "ABC's of 375/310."[9/] One explains the system, the other is a detailed guide through the nearly impenetrable thicket of regulations and directives.

The Department of Defense's position is that the intent of system management is not to put the detailed administration of development tasks in the hands of public officials,[10/] but to free its contractors to make decisions without undue interference. Or, in the words of an official

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[9/] The ABC's of Systems Management (Deputy for Systems Management, Aeronautical Systems Division, U.S. Air Force, 1 February 1965).

[10/] See, for example, Report to the President on Government Contracting for Research and Development (Washington, D.C.: Office of the White House Press Secretary, Monday, April 30, 1962) (Mimeographed), pp. 47-48.

spokesman of the Department of Defense:[11]

"I would also like to make it very clear from the outset that policy and procedural changes I will describe are designed not to provide rigidity or to inhibit judgment but rather to establish a framework within which the widest discretion may be exercised in dealing with each individual transaction...Primarily we are seeking to assure that such discretion is exercised with an excellent understanding of the facts of the individual case and of the Department's overall objectives. Secondarily, we are also seeking to find ways to give wider latitude to the management judgments of our contractors with the assurance that their motivations are always consistent with our objectives. By this means we expect to reduce government intervention in corporate management..."

However, in view of the sheer number of directives and their specificity and incorporation into contracts by reference, this laudable intention will be difficult to attain. It has not been attained in the recent past. Instead, the more general practice has been a literal, legalistic, and "safe" interpretation of the "book." It is difficult to see how increasing the number of directives which apply to industry, then placing these detailed regulations in the hands of the average contract administrator, will increase the contractor's freedom.

System management is clearly desirable. No organization other than a department of the government can manage the creation and integration of a total system such as Apollo, the C-5A Transport, or the F-111 Aircraft.

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[11] Speech by The Honorable Graeme C. Bannerman, Assistant Secretary of the Navy (Installations and Logistics), Los Angeles, California, March 3, 1965.

The application of system management at the same level of detail for small, one-of-a-kind developments, where producibility and support may not be key considerations, is another matter.

Program Budgeting

Program budgeting was introduced into the Department of Defense to provide a method whereby the Secretary could choose among competing, alternative systems and then budget for the total costs of acquiring these systems. Like system management, program budgeting is an effort to identify the functions or benefits performed by a system and to compute the total costs, over time, of developing and acquiring this system.[12/] Unlike system management, it compares the costs and benefits of competing programs to determine which of the proposing agencies will get the funds to build the system. The Army, Navy, and Air Force now compete for justification of plans and programs at the highest level, rather than for funds to spend on projects they may select.

This new approach to the budgeting problem was effectively introduced into the Department of Defense by Secretary McNamara early in 1961 when he became seriously concerned with the inadequacy of management techniques and attendant poor control over costs, performance, and schedules. Cost overruns and schedule slippages were common. The development and the production of some systems had been undertaken before either the requirements had been defined or it had been determined that the technology existed to construct or support the system. In many cases Secretary McNamara felt that insufficient attention had been paid to either the total cost or to the question of whether the function the system was to perform would justify the cost in

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[12/] See Air Force Regulation 375-4, System Program Documentation, 25 November 1963, pp. 7-12.

comparison with other, competing systems.

Program budgeting attempts to identify all the costs (development, production, and support) of a program or a system over its lifetime, and relate these to the functions or benefits which the program will provide.[13] Once these costs and benefits have been identified, the decision to fund the program can be made at the highest level, where it is possible to compare the program with competitors for the always-limited funds available.

It is possible to use this new device not only as a planning and decision-making tool, but as a control device to hold subordinate agencies to their estimates of cost and schedule which were the basis for approving the program in the first place. This requires a continual review of the program status, and a detailed, prescribed procedure for changing the approved cost, schedule, or performance parameters to prevent evading Department of Defense decisions.

The involvement of the Department of Defense (and this would apply to the top level of other agencies) in decision-making at this level of detail has led to at least four changes in the government-contractor relationship. First, is a sizable increase in the back-up data needed to get a program approved.

Second, there has been an increase in the Department of Defense's efforts to improve its cost estimating abilities. The Services, for example, have always felt handicapped in this regard, especially in evaluating bids and proposals. Now the Department of Defense believes that its cost estimating and tracking ability must be improved to verify the credibility of the Service estimates, and to control expenditures to budgets. These

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[13] Ibid., p. 11.

two changes require an independent source of data, largely obtained from industry.

Third, programs are now subjected to a closer review and continued justification at the Department of Defense level. This scrutiny is felt down through all echelons to the lowest project manager, in increased control over his project.

Fourth, increased attention has been paid to the development phase, since decisions during this phase affect not only the cost of the development but the cost of production and operation of the system. Thus, any serious attempt to apply program budgeting must start at the proper point in the research and development sequence. Realistic goals for cost, schedule, and performance must be established before starting development.

To accomplish these objectives, several significant steps have been taken by the Department of Defense which relate to program budgeting and affect the construction of a prototype.

First, all research and development programs are no longer grouped into one category, all competing for one source of funds. This would now be inappropriate, given the objective of identifying and comparing the benefits of each project. There is no easy way of comparing the benefits of research in high energy physics, for example, with those resulting from the construction of a new rocket booster. Different categories of work, previously bracketed together as Research and Development (R&D) need quite different management techniques. Accordingly, the total field has been divided into six categories:[14/]

[14/] See Department of Defense Instruction 3200.6, Reporting of Research, Development, and Engineering Information, June 7, 1962, for the official definitions and descriptions of these categories.

1. Research,
2. Exploratory Development,
3. Advanced Development,
4. Engineering Development,
5. Management and Support, and
6. Operational Systems Development.

The developmental projects which we have studied probably would have been classified in the Engineering Development category. As we progress up the spectrum of these categories (from Research), the Department of Defense contends that the amount of risk or uncertainty connected with the development lessens, hence projects can be more completely described in the later categories. The position of the Department of Defense is that no large development will be undertaken until the risk has largely been eliminated, that is, most of the unknowns have been identified and solved in the early categories of development.[15/] The intention is to minimize the chance of making large outlays of funds against concepts which might not be feasible, and which might have excessive elements of risk or uncertainty.

Before any development which is expected to cost over $25 million can be approved through the budgeting process, it must pass through a screen called "Contract Definition Phase." This screen is intended to confirm or deny a conditional decision to proceed with the development. The decision to start the Contract Definition Phase of project development depends on

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15/ See Department of Defense Directive 3200.9, Initiation of Engineering and Operational Systems Development, July 1, 1965, which states: "Projection into engineering development of anticipated developmental achievement will be permitted only when sufficient quantitative results have been obtained, in laboratory or experimental devices, to allow such projection with a high confidence..."

many criteria.[16/] Certain are significant to our study. Among these are prior demonstration that:

1. Primarily engineering rather than experimental effort is required,

2. The "building block" components and technology needed are sufficiently in hand, and

3. The cost and schedule estimates are credible and acceptable.

These key criteria indicate that it is no longer the intention of the government to fund developments unless they can be proven in advance; that is, there must exist a high degree of confidence in the probably outcome.

Contract Definition begins with the solicitation of proposals from qualified contractors (three are desired in an effort to maximize competition), each of whom is expected to determine the overall design and define the subsystems and components. The amount of data and detail generated by this approach is incredible. The C-5A aircraft, admittedly an extremely large development, yet one well within the state of the art, passed through the screen of Contract Definition. Each of the airframe contractors submitted a proposal averaging over 60,000 pages! The Air Force asked for multiple copies, which brought the total weight of paper from each of the individual proposers to over 20,000 pounds![17/]

While Contract Definition is an effort to prevent future mistakes and to insure that the product can actually be built, a question arises as to

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[16/] See Department of Defense Directive 3200.9, op. cit., for the official statement of these criteria.

[17/] Speech by Assistant Secretary Marks, op. cit., p. 9. Assistant Secretary Marks seriously doubted if the proposals could be read in detail and studied in depth, yet data from them will be incorporated into the contract and the work statement, binding the contractor to certain specifications which might later prove either impossible to fulfill or not in the best interests of the government or the contractor.

whether it is possible to prove a technical approach prior to building the complete item. It may be that the administration of Contract Definition will result in discouraging bold planning, since the contractor who should do such planning must disclose his approach in advance and it may leak to his competitors. Regulations governing the conduct of the contract administrator for the Contract Definition Phase prohibit his talking with one of the competing contractors unless the others are present. Thus, if a contractor is considering a novel approach, he may find it difficult to conceal this fact. He may be better advised to stay with the already approved concept, since this will be the basis of proposal evaluation by the Source Selection Board. Thus, a "sure bet" may have a greater chance of obtaining funds under program budgeting since one of the intentions is to discourage high risk efforts. The result may be small rather than large advances. Finally, the time for development will inevitably be lengthened while concepts are being written and approved, RFP's and proposals in response to them prepared and evaluated, and contracts negotiated and administered.

As one of the project managers we interviewed stated: "It [Contract Definition] is unworkable since the Department of Defense is trying to make decisions on paper [in the Concept Definition Phase] which can be made only in the presence of actual hardware. The total costs will rise, for the time from concept to service will be longer, partially due to the number of levels up to and including the Department of Defense who now review and can say no to each decision. The only savings may be that the production of totally worthless hardware should be prevented."

While Contract Definition technically does not apply to projects which are planned to cost under $25 million, in actuality its principles and methods do. Proposals now must be justified in detail and their feasibility demonstrated before funding is possible. Therefore, project managers are now faced with detailed control in the form of specific contracts and work statements, and specified approaches, prior to the start of projects.

Multi-Incentive Contracting

The Department of Defense believes that the principle underlying incentive contracting is that a contractor can be motivated, in calculable monetary terms, to turn out a product that meets advanced performance goals, to improve schedules and substantially reduce the costs of the project.[18/] If this principle is true, a benefit of this form of contracting would be to remove some of the restrictions and controls surrounding project managers and thus provide a looser rein. However, even an official Department of Defense spokesman, Assistant Secretary of the Air Force Leonard Marks, Jr. qualified the potential of incentive contracting to restore some freedom in these words: "...there appears to be a false impression on the part of many that a well-written contract assures a well-managed program. Although a well-written contract and supporting work statement are essential, we find today that most contracts are subject to a multitude of changes..."[19/] (Underlining added.)

The net result of incentive contracting, as administered and applied to development contracts, may be to increase rather than decrease control, raise costs, and decrease performance under development contracts. At present, these are assertions which cannot be fully proven, for the wide application of these contracts is still too new for definite conclusions to be reached. There are obvious disadvantages to this form of contract, most

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[18/] Incentive Contracting Guide (Department of Defense, 1963), p. 1.

[19/] Speech, Assistant Secretary Marks, op. cit., p. 11.

of which relate to the specificity required of the work statements. These disadvantages raise serious doubts concerning the multi-incentive contract's widespread applicability to development. The effects of multi-incentive contracting should be studied very carefully before these forms are widely applied to research and development contracts, for there is still great disagreement about whether these forms, which the Department of Defense states are "used to increase technological progress and provide cost savings,"[20] are in fact beneficial. Scherer has stated that: "Contractual incentives can have only <u>limited</u> effectiveness during the development stages of a weapons program. Contract provisions which correlate development profit with quality and schedule outcomes tend to be redundant since there exist more powerful sales-oriented competitive incentives on these dimensions."[21] (Underlining added.)

The requirement for precise, definitive contracts and work statements, not appropriate to developments requiring innovation and creativity (with the attendant uncertainty), makes contract administration difficult. If the specifications are sufficiently unequivocal to serve as the basis for cost, schedule, and performance targets, they increase the constraints on the project manager, for he must define his task before starting, and then must attempt to stay within this "envelope" even in the face of later discovered alternative approaches and the inevitable "multitude of changes" which Assistant Secretary Marks states are inevitable.[22]

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[20] <u>Incentive Contracting Guide</u> (Department of Defense, 1965), p. 1.

[21] F. M. Scherer, <u>The Weapons Acquisition Process: Economic Incentives</u> (Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1964), p. 189.

[22] Speech by Assistant Secretary Marks, <u>op. cit.</u>, p. 12.

For example, if the contracting officer will not approve a change which the project manager knows is needed to reach the imposed goals, the firm is faced with the difficult decision of whether to approve the change unilaterally since all costs, even those allowable under other contractual forms, must be borne by the firm. The chance that contracting officers will make technical decisions is increased.

Two illustrations of the recent complication of "change management" come to mind. A manager of an electronic components project built the first five models to specifications although he knew their performance would be unacceptable. He felt that requesting a change at an earlier stage would be a mistake because it might not be approved, and in any case costs would continue while waiting for a decision. After the unsuitability of the components had been demonstrated, the customer had no choice but to re-write and renegotiate the fixed price incentive contract, at a higher target cost, and to pay for the costs of developing the five unsatisfactory models.

Another project manager did not follow the specifications precisely nor attempt to have them changed. Instead, he built certain computer components which, at least in his opinion, really met the customer's requirements. Also, they apparently met performance specifications. However, since the firm had not followed the work statement exactly, it was held to the written specifications and required to rework at no cost to the Government.

Thus, there is a great risk that the inappropriate application of multi-incentive contracts to development can discourage innovation and creativity, since changes to a precisely specified contract and work statement are difficult and time-consuming to negotiate. As stated above, the time required to have changes approved has apparently lengthened, yet the firm's costs continue while the project may be either idled or halted. Project managers have contended that contracting officers do not act on change requests promptly, perhaps not fully realizing that the costs of delay are no longer borne by government, as in the days of cost plus contracts, but by industry.

Multi-incentive contracts, if used inappropriately, can slow down the process of development because of the need for specificity of contracts and work statements and the increased difficulty in obtaining approval of change requests.

Provisions for Relaxing Tight Control

Nearly all of the newer directives noted above contain provisions which allow a loose rein. Exceptions are either difficult to obtain, however, or lower administrative levels have applied tighter restrictions than the initiating agency demands. Consider the following representative examples:

1. The Department of Defense does not require system/project management for development projects which are estimated to cost under $25 million.[23/] "Loose" rein should be possible for many of these less costly projects. But, the Department of Defense further qualifies its position: "Other systems/ projects may be designated for this exceptional management by the Secretary of Defense or the Head of a DOD component [i.e. the Air Force]...[but] discretion should be exercised in the optional application of exceptional management technique..."[24/] (Underlining added.)

Rather than exercising discretion, the Air Force's position is more rigid. Its official doctrine is that system management applies to all projects in the Engineering Development category and most of the projects in

23/ Department of Defense Directive 5010.14, op. cit., p. 3.

24/ Ibid., p. 12.

the Advanced Development category.[25]

2. Contract Definition may be waived, but only on application to the Secretary of Defense or, for lesser projects, to his Deputy for Research and Engineering. This application must be made by the component concerned, i.e. the Air Force.[26]

The Air Force again has extended the application of Contract Definition beyond the prescriptions of the Department of Defense by stating that Contract Definition may be applied to other projects, if they have been selected for system management.[27]

3. The Armed Services Procurement Act of 1947 limits the fee payable on research and development contracts to not more than 15 per cent of the original estimated costs. ASPR 3-4055.5(c)(2), however, has reduced this amount to 10 per cent by stating that the head of the procuring agency has authority to approve fees of only 10 per cent of the estimated costs under research and development contracts.

Summary

The number and specificity of procurement directives has not grown for trivial administrative purposes, but because the government has sincerely been trying to reduce the costs and time for the development of large systems. There are three main areas of increasing control which particularly affect the research for and the development of prototypes:

a. An increased centralization of decision making, illustrated by the system management type of directive. This centralization appears appropriate

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[25] Air Force Regulation 375-1, op. cit., p. 1.

[26] Department of Defense Directive 3200.9, op. cit., p. 11.

[27] Air Force Regulation 375-5, Definition Phase of System Life Cycle, May 4, 1964, p. 1.

for large systems but not for smaller projects.

b. An increase in the long-range planning and programming ability of the government, exemplified by program budgeting and Contract Definition which supports it. We concur that the production and support of large systems must be carefully planned and budgeted. We do not agree that one can always plan in detail for innovative development in advance of building a prototype.

c. Multi-incentive contracting has grown from 15 per cent of the total Department of Defense budget in 1962 to 56 per cent in 1965. These contracts may be appropriate to production efforts, but if not administered properly may inhibit innovative and creative efforts.

IV

LIMITATIONS OF LOOSE-REIN MANAGEMENT

While great advantages can result from the type of loose-rein management described in Part II, it has important limitations. Following are a few.

First, project management of the type discussed in this Report requires superior managers and above-average top staff. The project manager is a key figure. While the characteristics of project managers studied for this Report varied greatly, they all seemed to have two essential qualities. They all were able to lead their teams in such a way as to induce high creativity, productivity, and morale. They also were able to adjust their managerial styles to fit differing requirements as the project moved through the phases of basic research, design, development, and construction of prototype.

It is not asserted that it is necessary to be a genius before the juicy fruits of loose-rein management are harvested. Nor can it be denied that superior management anywhere will produce superior results. It does seem true, however, that the requirements for successful loose-rein management do seem to demand above-average technical and management talents.

Quality staff also is required. The team needs highly creative people who are able and willing to perform a variety of tasks. It is difficult to see how the required "imagineering" can be done with a mediocre staff.

Second, both contractors and the procurement agencies must want to operate with a loose rein. So far as contractors are concerned, there are problems with this management style. As noted above, highly competent people must be assigned to the project. Contractors may be reluctant to use them in a loose rein project because they may be needed on other projects. But also, fewer people are required than might be acceptable to the government under an arrangement of tight controls. This, together with cost and time savings, if they are very important, might reduce total expenditures and profits. Under incentive contracting, however, just the reverse profit might occur. Then, too, project managers need authority, as noted in Part II. This may cause some difficulties in the operation of the contractors' plant.

So far as the government is concerned, there are many reasons for being cautious about loose-rein management. Some of these were presented in Part III. In addition, quick decisions on the part of Project and Program Offices is necessary for loose rein to succeed importantly. Required is a system which permits such decisions and avoids disproportionate penalties for error. Military Officers who direct Projects not only must be allowed to make prompt decisions but must be encouraged to do so without fear of risking military careers. It is recognized that today this is not an easy requirement to meet. It is recognized, too, that various laws and regulations promulgated both by the Congress as well as in the Executive Office of the President place regulatory requirements on procurement agencies which may inhibit the use of loose-rein management.

Third, the model of Part II clearly is inapplicable to very large projects and to standard mass-production items. It is also inapplicable to pure research. Parts of the model, of course, may be applicable to each. But the loose-rein philosophy is not appropriate, for example, to the production of a new mass-produced manned fighter reasonably within the state of the art. Nor are the internal regulations of the model very applicable to a pure research project of small dollar dimensions and seeking new technical creations.

Finally, more research and study of the characteristics of loose-rein management and its applicability seem warranted. Lack of understanding of the method, particularly as it relates to the current, evolving procurement system, may be an inhibiting factor in expanding its use.

In sum, there are limitations on the use of loose-rein management model described in Part II. It is not universally applicable.

V

FURTHER SUGGESTED RESEARCH ON LOOSE REIN MANAGEMENT

The research results reported here are based upon rather limited analysis and investigation. Clearly, this is not an exhaustive examination of loose rein management. But the conclusion seems clear that further research will have important pay-off for both government procurement administrators and business contractors. A few areas of useful research are sketched below.

First, more project managers in a position comparable to those interviewed for the present Report should be studied. Are the philosophies, principles, and practices as universally applied as we found them to be? Are there additional important observations about the management of these men that should be introduced into the model? What changes in emphasis of different parts of the model become obvious with additional cases?

Second, careful study should be made of project managers who are thought to have used principles and practices comparable to this model but failed to achieve the results of those managers included in this survey. No managers of projects which failed were included in this study. It is important to find managers who have failed or did no better than ordinary work, but had a loose rein, to determine the causes of their shortcomings. Was it because of technical rather than managerial problems? Was it because of personal characteristics? Was it because of a failure to apply appropriately one of the major elements of our model?

Third, further research is appropriate into the question of why it is that loose rein management seems to stimulate more creativity. In this study the assertion was made frequently that the type of management practiced resulted in higher creativity. Much has been done to try to find out the bases for creativity. Rather than study the problem of creativity abstractly, it might be profitable to seek to determine to what extent the model presented here is helpful in stimulating creativity, as contrasted to a tighter managerial rein on the part of the customer. In a recent summarization of the characteristics of a creative organization, Professor Larry Cummings listed the following:

"1. A relatively small degree of formalization of relationships among the organizational positions, (Flexibility of structure may be a necessary quality of the truly creative organization);

"2. Careful attention given to <u>not</u> overspecifying the human resources needed for a specific task,

"3. A flexible power-authority-influence structure or network oriented primarily toward the task at hand;

"4. Relatively large areas of discretion and healthy amounts of participation and autonomy for those who are expected to exhibit creatively;

"5. Perhaps broadened spans of control to decrease the likelihood of management by direction and control. (This will probably mean flatter or at least non-pyramidally shaped structures);

"6. Measurement of results and the associated evaluation of personnel based on the longest time span compatible with economic survival;

"7. A tendency to utilize actual results accomplished within this time span, rather than the adherence to minutely prescribed procedures, as the standard for evaluation and measurement;

"8. A tendency to organizationally or at least conceptually separate the idea generation function from the idea evaluation function;

"9. A tendency toward the maximum number of open communication channels interconnecting all those knowledgeable units relevant to a particular problem area;

"10. A conscious attempt to institutionalize an organizational reward system, basically intrinsic in character, which appeals to the needs of the creative individual. (Suggestive mechanisms here might be considerable self-selection of task assignments, given some broadly defined constraints; increased freedom of work scheduling; increased autonomy concerning work methods, enhanced opportunities for professional growth and recognition; and, perhaps differential extrinsic reward systems for professionals and non-professionals involving parallel promotional chains based on different but appropriate criteria; and,

"11. Of primary importance, but somewhat intangible, a managerial philosophy and attitudinal climate which projects the assumption that employees are generally capable, well trained and able to exert creative efforts in the pursuit of organizational goals."[1/]

A penetrating study comparing several of the organizations examined in this Report with respect to those elements of the model which may yield higher creativity would seem useful. Definitely, this research should be interdisciplinary among management theorists, behavioral scientists, psychologists, and perhaps sociologists.

Fourth, closely associated with the above is the question of project manager motivation of people. While no attempt was made in this study to evaluate and measure the extent to which project managers motivated their people, it is clear that in every instance people were highly motivated.

[1/] Larry Cummings, "Organizational Climates for Creativity," Journal of the Academy of Management, Volume 8, Number 3, September 1965, p. 226.

As one project manager put the matter: "One of my major problems is sweeping the people out of the shop." What he meant is that they became so absorbed in their work they not only forgot about working hours but, in the project manager's judgment, spent more time on the job than was good for them and the project. Probably this happy result is due to a combination of influences--the personality of the project manager, working conditions, the nature of the project team, and the stimulation from the project challenge.

Clearly, when workers are so highly motivated one can expect that they will be more creative, produce a more reliable commodity, cut costs, and telescope time schedules.

People can, of course, be highly motivated in organizations not managed with a loose rein. The generality of high motivation found among projects studied, however, merits further examination to find out whether there is a reasonable correlation between the application of the model presented here and worker motivation.

Fifth, project managers in the area under investigation in this study cover a spectrum from research through development and into prototype production. All the managers interviewed were capable of managing through these different stages. Each one of these stages, however, requires different managerial capabilities. A study should be made of these differences. Such a study at a minimum should help to identify project managers capable of performing successfully with a loose rein in the research and development spectrum.

Sixth, deeper exploration of specific tools and methods for planning and control should be studied. In practically every case we found a mixture of standard planning and control tools and practices. Few, if any, identical applications of a particular tool were found in the study. For instance, many project managers used PERT, but not one used it in the same identical way as another. In addition, project managers developed their own unique control methods. These should be available to others.

Seventh, deep exploration should be made of the interrelationships between the Armed Services and NASA regulations on the one hand, and the management model on the other. As noted in Part III, for example, the Armed Services and NASA regulations do permit a wider use of loose rein, but actually this is not being done. It seems important to know why. Furthermore, the loose rein technique does not seem to fit too well in the present procurement system. Why is this so? Can anything be done about it?

Eighth, this question should be examined in depth: how can government procurement administrators tell when a loose rein is appropriate? It was noted before that there exists only a general and loose recognition of the areas of applicability of the model presented in this study. A more precise set of criteria governing its relevancy should be helpful in determining when and under what circumstances to offer it. Part of this study, of course, is identification of project manager personal characteristics, as well as managerial capabilities, which are important for success.

Finally, more study of an empirical nature needs be made of the interrelationships between loose rein management and incentive contracting. Many problems exist in this area. For example, despite the principles of incentive contracting which should result in loose rein, government procurement officers have not loosened the rein. The reasons why should be examined in depth. In addition, incentive contracting is not applicable where considerable uncertainty exists about design, cost, and schedule. Under these circumstances, other contracts may be more appropriate. Loose rein also might be appropriate. What is the mixture? Can a set of criteria be developed to help determine the better applicability of incentive contracting with loose rein, and loose rein with other type contracts?

In sum, while a good bit of theoretical work has been done on loose rein and issues connected with its application, much more knowledge would be valuable. The more knowledge which is available, the more both the government and the contractors can define risks, determine appropriateness, and fit it into the procurement system. The suggestion here is that the focal point for this research should be both the model presented in this study and empirical investigation among practicing project managers. Government procurement administrators armed with this research might be more easily persuaded to use loose rein management.

VI

SUMMARY AND CONCLUSIONS

This study concludes that fifteen project managers who had a loose rein from the government customer also had similar managerial philosophies and ran their programs on the basis of comparable principles and practices. They also were highly successful in producing a superior technical product at a minimum cost and time. These philosophies, principles, and practices are incorporated in the descriptive model presented in this study.

The research shows that while the project managers studied had differing degrees of freedom from government procurement regulations, they did not adopt free rein in the operation of their own projects. Their managerial principles were tough-minded and rigorously applied and enforced.

The use of this model should result in a success similar to that of the project managers interviewed, other things being equal. It therefore seems worthy of consideration by both government and industry.

Trends toward tightening governmental procurement regulations have been apparent during the past few years and are likely to extend into the future. Loose-rein arrangements seem to be declining in relation to total procurement actions. Also, the number of mass production programs is declining relative to total procurement action, and one- or few-of-a-kind research and development contracts are increasing relative to the total activity. In this light, and if the performance of loose-rein management is really as effective as here asserted, some reversal of trends should take place.

This study does not conclude that loose-rein management be expanded rapidly and indiscriminately. This technique has limitations. Major limitations exist in the problem of finding the talent needed for loose rein project leadership; in availability of the high-quality personnel required for the team; in reservations and mental blocks, despite assertions to the contrary, that both contractors and government procurement administrators sometimes have; in the inapplicability of the method to large production programs or very small basic research programs; and in the fact that the pool of knowledge about loose-rein project management needs expansion for better understanding of its strengths and limitations.

In this light, it is recommended that government procurement agencies should anticipate substantial returns on investment on selected types of research concerning loose-rein management. Major research topics would include the following: further depth interviews of successful project managers to test the model of this study; study of unsuccessful project managers who apparently used a comparable managerial model to determine the reasons for failure; research into why loose-rein management and the model described in this study seem to stimulate more creativity than is usually the case; research as to why all the project managers of this study seemed to have had a project team motivated to a high pitch; differing managerial requirements for research, development, and production of prototypes; interrelationships between the Armed Services-NASA regulations and the loose-rein managerial model; criteria for determining when loose-rein management is most appropriate; the interrelationship between loose-rein management and incentive contracting.

The major conclusion of this study is that more loose rein arrangements should be made by government procurement agencies. Important benefits can accrue to the government from the application of this technique in fairly large and complex research and development programs. These benefits are in terms of superior technical product at lower cost and in less time. The government and contractors should pay more attention to this method. More risks should be taken in applying it. In the meantime, more study should be made of it so that risks taken in the future can be more precisely defined, narrowed, or eliminated.